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Development of Representative Driving Patterns at Various Average Route Speeds

Scott Research Labs, Inc, San Bernardino, Calif

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16 ABSTRACT

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The major findings of the study were:

1. In the case of the HC and CO emissions, an adequate fit to the data is obtained by plotting the natural logarithm of each emission against a quadratic function of average route speed.
2. A simple linear plot of NO_x against average route speed was deemed to provide an adequate fit to the data.

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1.0 SUMMARY

This report presents the results of a study performed for the purpose of updating the curves used to estimate the changes in emissions from light-duty vehicles as the average vehicle speed is varied. The program objective was accomplished by performing four major tasks as follows:

1. Urban driving pattern data collected during the CAPE-10 Vehicle Operations Survey, conducted in 1971 under the joint sponsorship of EPA and CRC, were processed by city and time of day into freeway, non-freeway, and composite speed-mode matrices.

2. Weighted combinations of freeway and non-freeway matrices, representing average route speeds ranging from about 34 to 76 kilometers per hour (kph) (21 to 47 miles per hour (mph)), were then used to generate representative driving patterns at speeds ranging from approximately 24 to 72 kph (15 to 45 mph). Eighty-eight driving patterns were selected as most representative out of a total sample of about 150,000 computer generated driving patterns.

3. Second-by-second schedules of the 88 driving patterns were then input to an EPA-supplied computer program for the estimation of HC, CO, and NO_x emissions over each driving pattern for each of 11 vehicle groups defined by model year and altitude (low altitude vs. high altitude). The EPA-supplied computer program is based on the results of several emissions testing programs conducted for the EPA.

4. A regression analysis was then conducted to relate estimated emissions to average route speed for each of the 11 vehicle groups.

The major findings of the study were:

1. In the case of the HC and CO emissions, an adequate fit to the data is obtained by plotting the natural logarithm of each emission against a quadratic function of average route speed.

2. A simple linear plot of NO_x against average route speed was deemed to provide an adequate fit to the data.

It must be noted that the regression relationships are valid only within the range of 24 to 72 kph (15 to 45 mph). Extrapolations to higher speeds will yield incorrect values of the emissions for each vehicle group. Since there is considerable interest in emissions at the higher speeds, it is recommended that additional driving patterns at speeds up to about 97 kph (60 mph) be generated and a regression analysis be conducted to obtain improved speed correction factor curves.

2.0 DRIVING PATTERN DEVELOPMENT

The development of driving patterns at speeds ranging from about 24 to 72 kilometers per hour (15 to 45 miles per hour) will be described in this section in terms of the following:

1. Data Processing
2. Mathematical Model
3. Driving Pattern Selection.

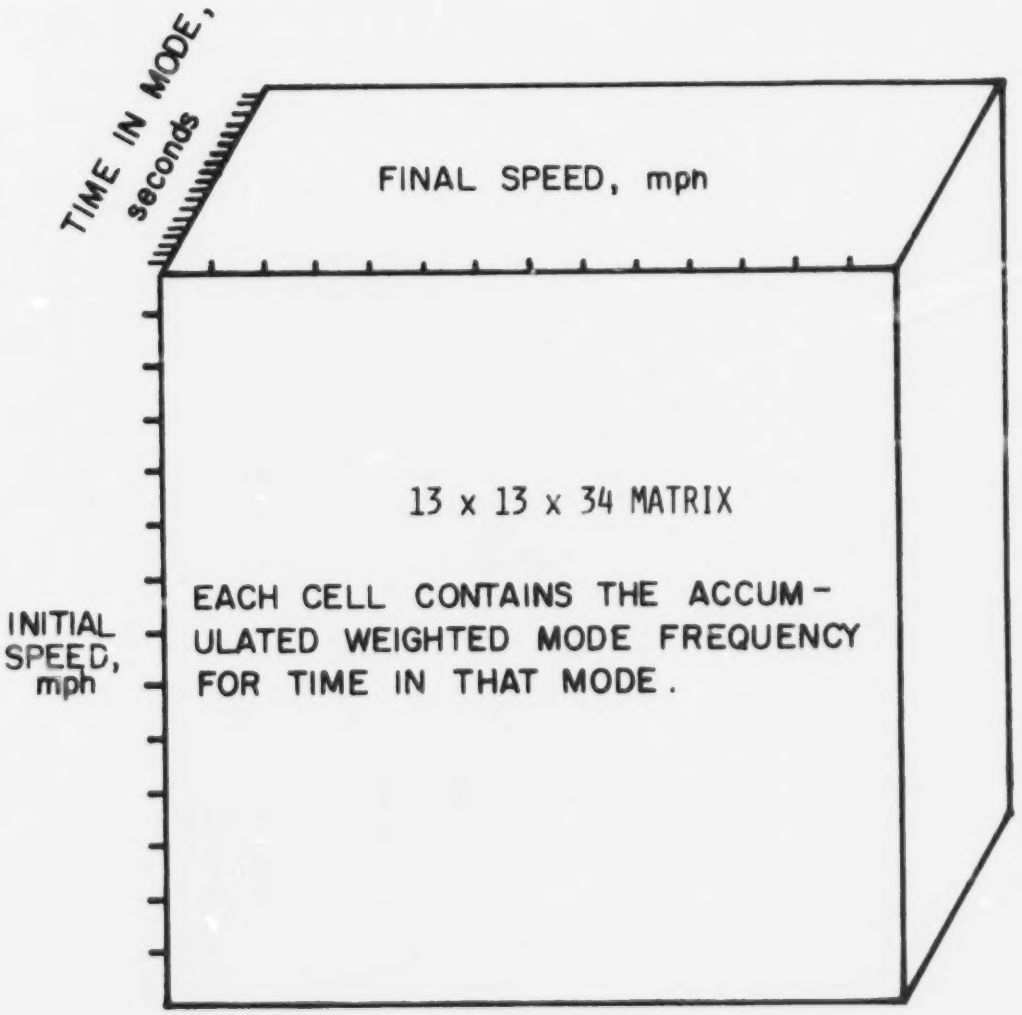
2.1 DATA PROCESSING

The data used as input to this project were obtained from the CRC/APRAC-CAPE-10-68 program conducted by Scott and referred to as the Vehicle Operations Survey (VOS) program. The primary objective of the VOS program was to collect and evaluate information on urban driving patterns as characterized by detailed vehicle modal operating characteristics.

Vehicles instrumented with Digital Data Acquisition Systems (DDAS) were used to obtain the detailed vehicle modal operating parameter information. Of the extensive data collected during the VOS program, basically two measurements, speed and time, are of direct use for purposes of representative driving pattern development. A precision electric speedometer (rotary pulse generator) was used to monitor the speed of each instrumented vehicle, and an electronic oscillator provided highly accurate time determinations. Speed, time, and other data were recorded digitally on magnetic tape to facilitate computer processing.

All data, including vehicle speed, were recorded at one-second intervals. Since the rotary pulse generator was calibrated to an accuracy of 0.1 mph, cruise speeds could be determined to 0.1 mph, and accelerations and decelerations could be measured to an accuracy of 0.1 mph/second.

The basic matrix used to accumulate the modal data is the 3-D matrix shown in Figure 2-1. An 8-kph (5-mph) speed increment was found to be adequate and convenient for use in defining the speed modes. Since verification of the driving patterns on a chassis dynamometer is an important consideration, and since most Clayton dynamometers are restricted to a speed of 97 kph (60 mph), the thirteenth matrix element represents 97 kph


TIME IN MODE, seconds
FINAL SPEED, mph
13 x 13 x 34 MATRIX
EACH CELL CONTAINS THE ACCUM-ULATED WEIGHTED MODE FREQUENCY FOR TIME IN THAT MODE.
INITIAL SPEED, mph

DISTRIBUTION-OF-TIME-IN-MODE MATRIX

FIGURE 2-1

and over (60+ mph). These modal data were then transformed into two basic matrices: a total-time-in-mode matrix and a mode-frequency-of-occurrence matrix, in the format shown in Figure 2-2. The matrices used to describe and develop driving patterns are defined more specifically as follows:

Distribution-of-Time-in-Mode Matrix: This matrix, shown in Figure 2-1, is a 3-dimensional matrix, the third dimension reflecting the distribution of time in mode for each mode. It is the basic matrix from which both the total-time-in-mode and mode-frequency-of-occurrence matrices are created.

Total-Time-in-Mode Matrix: The time spent in executing each mode was accumulated to yield the 2-dimensional total-time-in-mode matrix, formatted as shown schematically in Figure 2-2; each entry is the total observed time, normalized so that the sum of all entries is 100%.

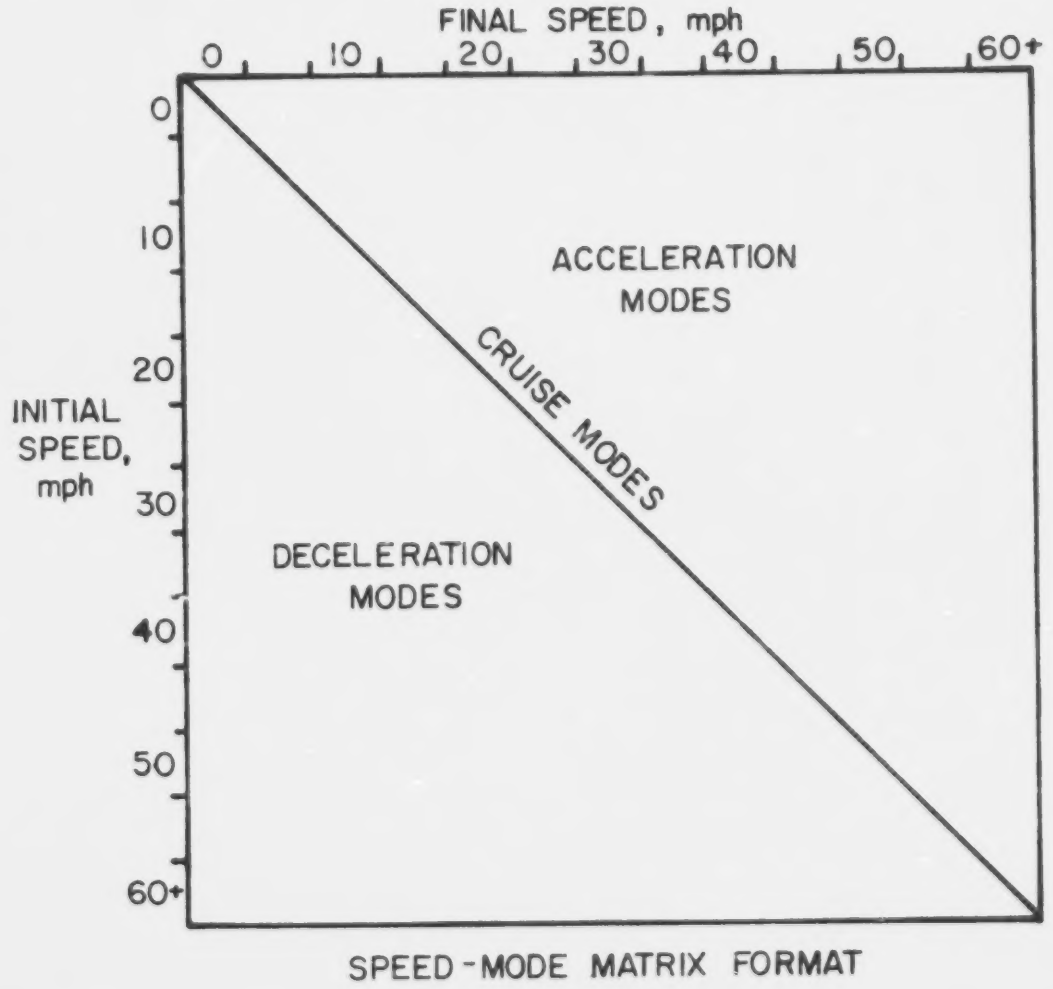
Mode-Frequency-of-Occurrence Matrix: This 2-dimensional matrix, formatted as in Figure 2-2, was derived from the distribution-of-time-in-mode matrix by simply tallying the number of times each mode occurred and then normalizing so that the sum of all entries is 100%.

Average-Time-in-Mode Matrix: This matrix is generated by dividing each element in the total-time-in-mode matrix by the corresponding element in the mode-frequency-of-occurrence matrix.

Transition-Probability Matrix: This matrix, formatted as in Figure 2-3, is obtained by row-normalization of the mode-frequency-of-occurrence matrix. I. e., the non-diagonal elements in each row of the mode-frequency-of-occurrence matrix are first summed, and each non-diagonal row element is then divided by the row total. The off-diagonal entries in any row are therefore the conditional probabilities of making transitions from the row's cruise mode (diagonal element) to those acceleration or deceleration modes. The diagonal elements in the transition probability matrix remain undefined, of course, since no transition occurs while cruising.

2.2 MATHEMATICAL MODEL

A Monte-Carlo model was chosen since that technique allows the rapid generation of large numbers of driving patterns from which those most representative of observed driving patterns may be selected. Patterns are generated by randomly selecting modes and mode durations by sampling the



SPEED-MODE MATRIX FORMAT

FIGURE 2-2

TRANSITION-PROBABILTY MATRIX (PERCENT):

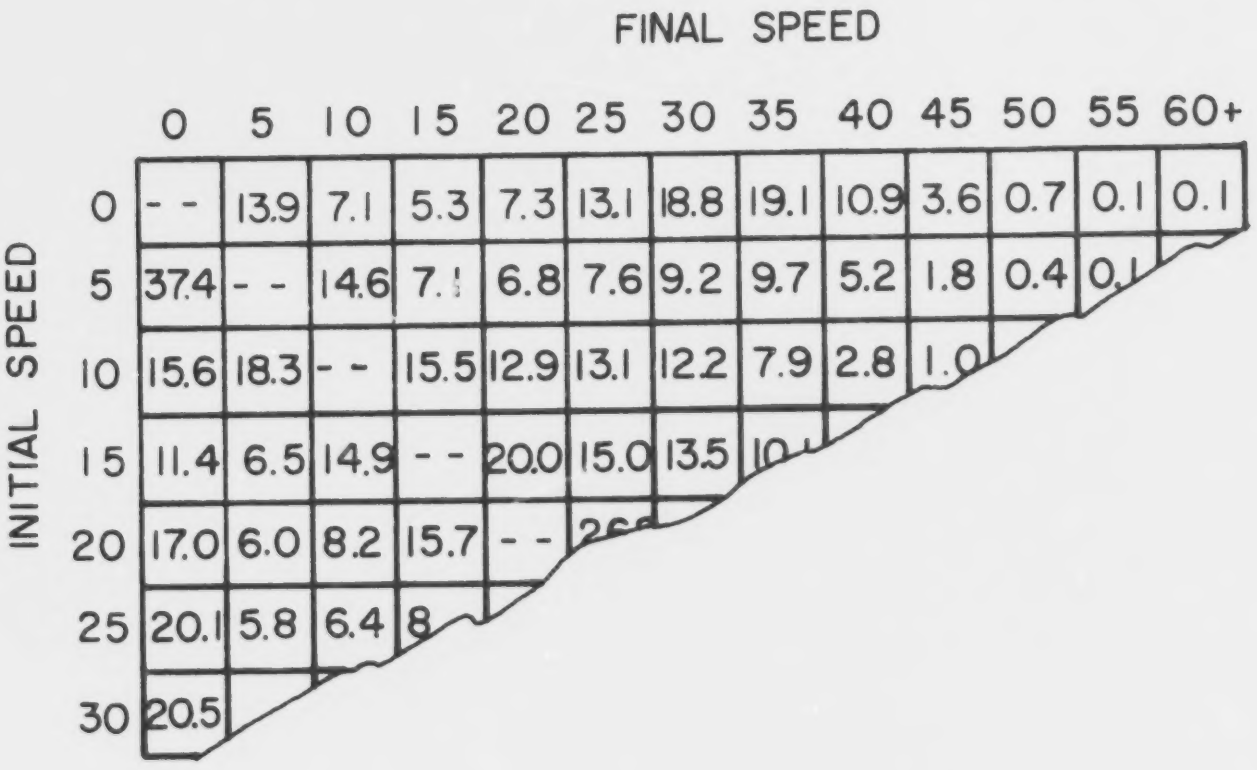


FIGURE 2-3

distribution functions for each with random numbers. Before proceeding further, however, it is appropriate to note the mode-sequence logic employed:

a) A cruise mode can be either an idle mode or a non-zero constant-speed mode.

b) Every other mode in a cycle is a cruise mode; i.e., every acceleration or deceleration is followed by a cruise mode; zero-time cruises are admissible, but were not utilized for this program.

In order to privide a basis for the mode selection process, the transition-probability matrix is recast in the form of running sums to the right on a row-by-row basis. This new matrix, the cumulative transition-probability matrix, is shown in Figure 2-4. (In all that follows, the random numbers generated are uniformly distributed on the unit interval.)

Execution of a cruise mode defines the matrix row from which to select the next mode by virtue of the mode-sequence logic. A random number on the unit interval is then generated to sample the distribution function for that row and thus select the next mode. Examination of Figure 2-4 shows, for example, that if an idle had just been executed and a random number of 0.539 generated, the mode selected is an acceleration from zero to 48 kph (0 to 30 mph).

The VOS data were processed to output the speed-versus-time data for any specified acceleration or deceleration. A large number of such acceleration and deceleration data sets were normalized in both speed and time, plotted, and carefully compared for trends in curve shape differences.

It was found that virtually all decelerations followed the same normalized curve, independently of initial and final speeds. The accelerations, however, could not be accurately represented by a single normalized curve, but rather required classification into three distinct normalized acceleration curves. These and the deceleration curve are shown in Figure 2-5.

The acceleration characteristics were found to be functions of both initial speed and net change in speed, as noted in Figure 2-5. The computer was thus programmed with polynomials fitting the curves shown in the figure. The transitions made between cruise modes in the test cycles are therefore representative of those observed in the five cities surveyed.

CUMULATIVE TRANSITION - PROBABILITY MATRIX (PERCENT):

FINAL SPEED

INITIAL SPEED	0	5	10	15	20	25	30	35	40	45	50	55	60+
0	0.0	13.9	21.0	26.3	33.6	46.7	65.5	84.6	95.5	99.1	99.8	99.9	100.
5	37.4	37.4	52.0	59.1	65.9	73.5	82.7	92.4	97.6	99.4	99.8	99	
10	15.6	33.9	33.9	49.4	62.3	75.4	87.6	95.5	98.3	99.3			
15	11.4	17.9	32.8	32.8	52.8	67.8	81.3	91.4					
20	17.0	23.0	31.2	46.9	46.9	73.9							
25	20.1	25.9	32.3	40.0									
30	20.5	29											

FINAL SPEED AFTER AN IDLE

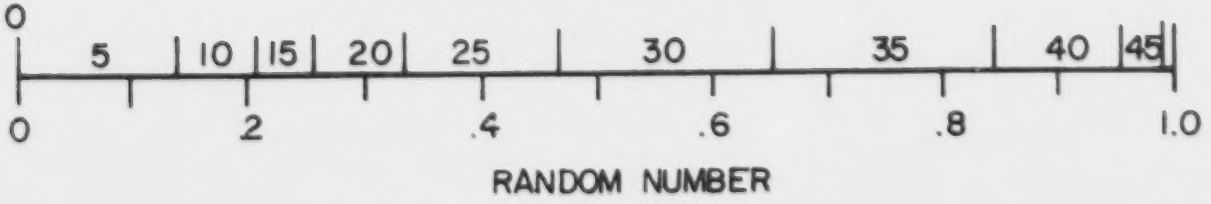
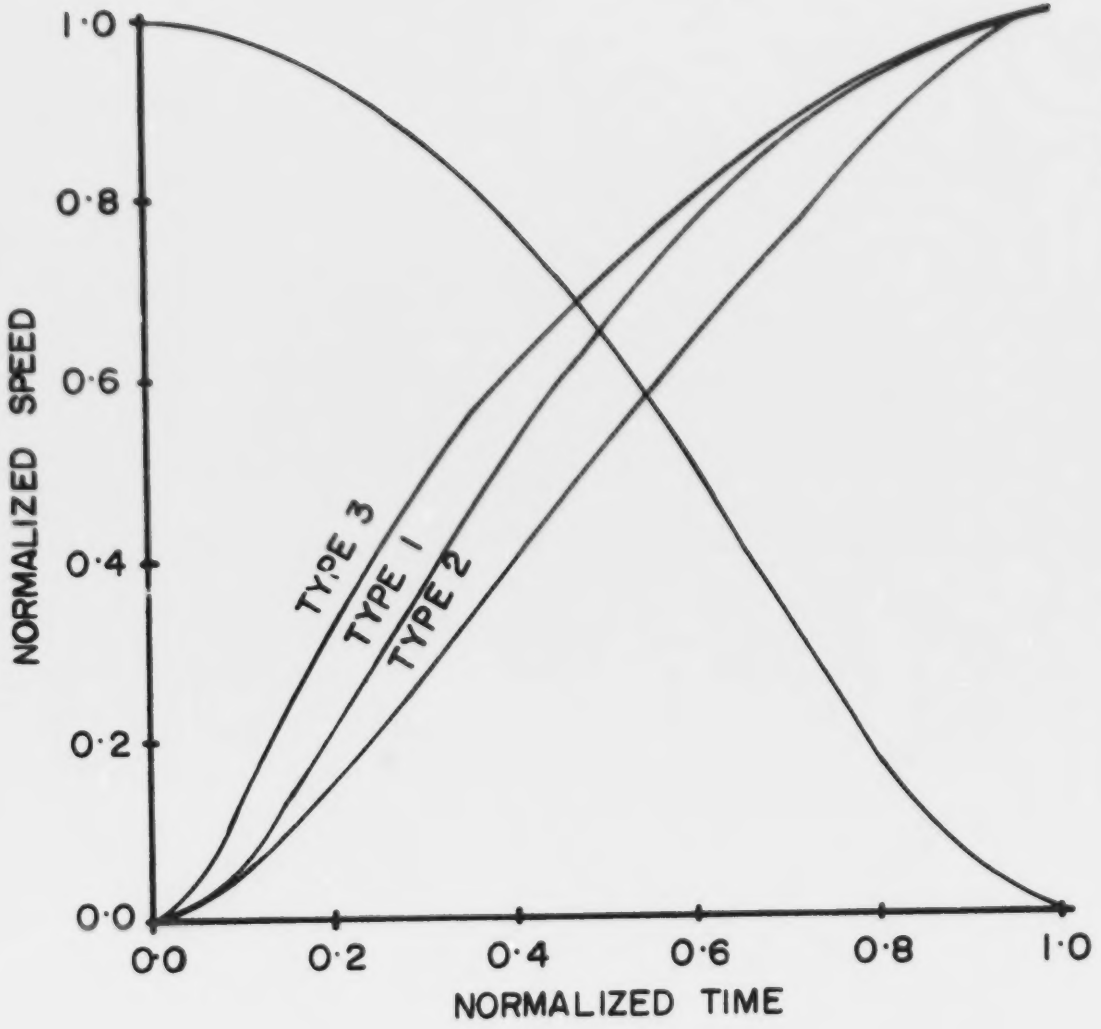


FIGURE 2-4



TYPE 1 : $0 < \Delta S \leq 35,\ S_I = 0$
TYPE 2 : $0 < \Delta S \leq 35,\ S_I > 0$
TYPE 3 : $\Delta S > 35$

UNIVERSAL ACCELERATION AND DECELRATION CHARACTERISTICS
FIGURE 2-5

SRL 2148 07 0274

The distribution-of-time-in-mode matrix yielded, for each mode, a frequency distribution such as that illustrated in Figure 2-6. By creating equal intervals along the abscissa of the time distribution curve, stepwise integration leads to a histogram as shown. After normalizing the area under the histogram, the Monte-Carlo technique is applied to time-in-mode selection. It should be noted that probability is again reflected along the random number axis, and that the most probable time in mode is the average time in mode.

The sequence in which the selections are made is shown in the condensed functional flow diagram of Figure 2-7. The total-time-in-mode and mode-frequency-of-occurrence matrices are input to the computer and the cumulative transition-probability matrix is created. The program then passes through reference point one, which denotes the point at which mode selections are initiated.

Since patterns must be of finite duration and it is desirable to end them with an idle mode, the program tests each cruise mode to determine if it is an idle. If it is not, the program returns to reference point one. If it is an idle, the program tests the pattern duration to that point to determine whether the desired duration has been either reached or exceeded. If the duration is less than desired, the program returns to reference point one. If the desired duration has been exceeded, the process is terminated.

If the duration is within the established limits, the pattern is tested to determine whether it is representative of (similar to) the observed vehicle operation patterns used as inputs. If certain criteria are met, the pattern is retained in storage. If it is found not to satisfy the criteria, the pattern is erased from storage after the pattern-evaluation data are stored for statistical purposes. After each such test, the program is either terminated or returns to reference point one to generate another pattern.

2.3 DRIVING PATTERN SELECTION

Three types of pattern evaluation measures were used: correlation coefficients, G-values (a chi-square equivalent), and summary measures, as summarized in Table 2-1.

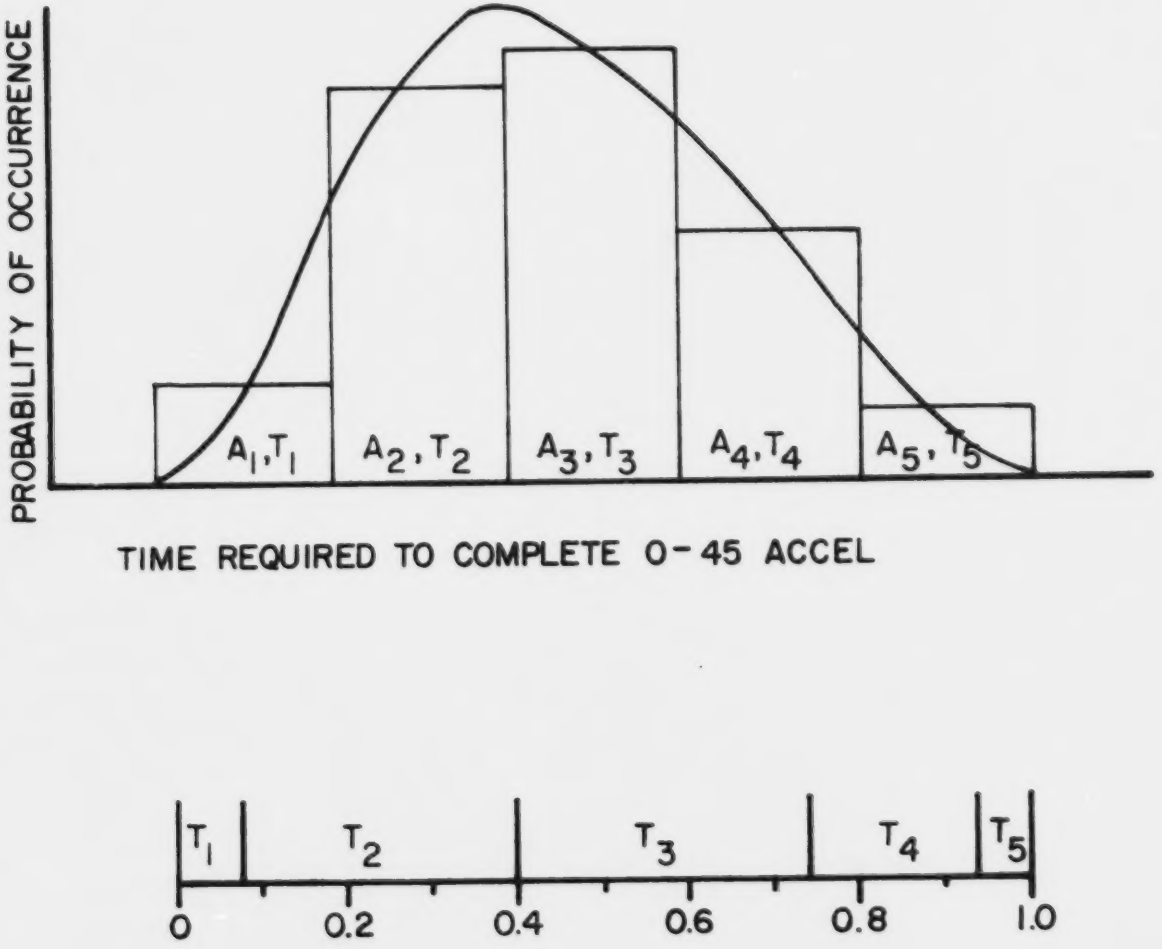


FIGURE 2-6

DESCRIPTION OF MONTE-CARLO SELECTION OF TIME IN MODE

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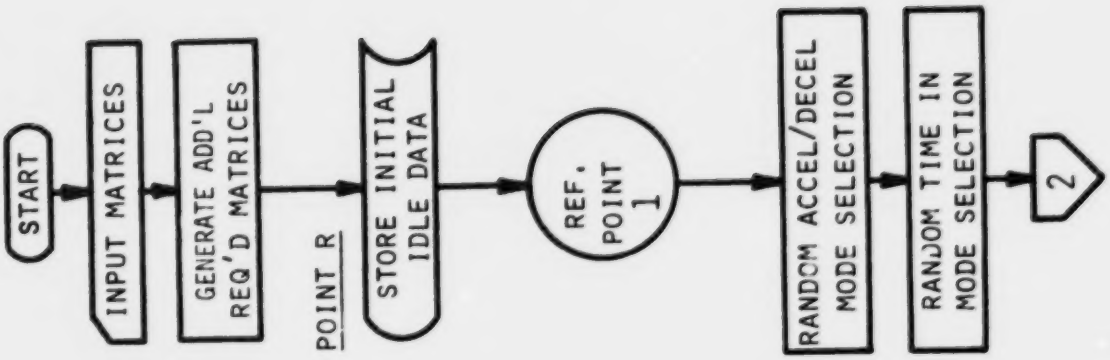

FIGURE 2-7

CYCFILTR PROGRAM

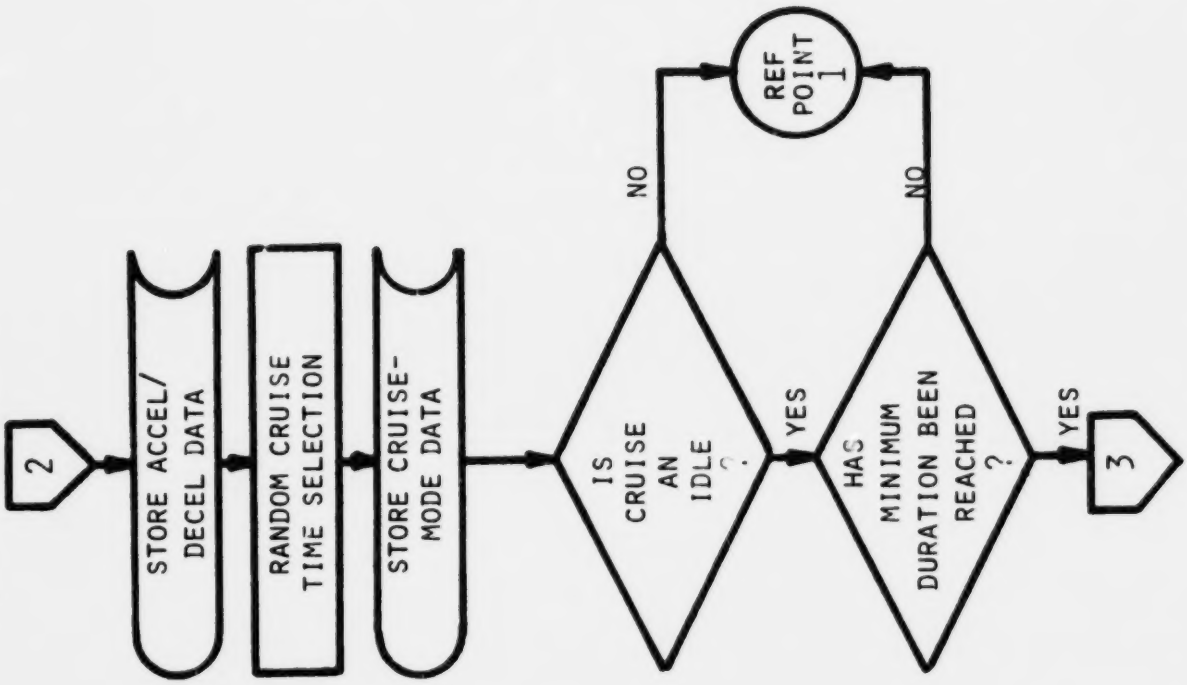

FIGURE 2-7 (CONT'D)

SRL 2148 07 0274

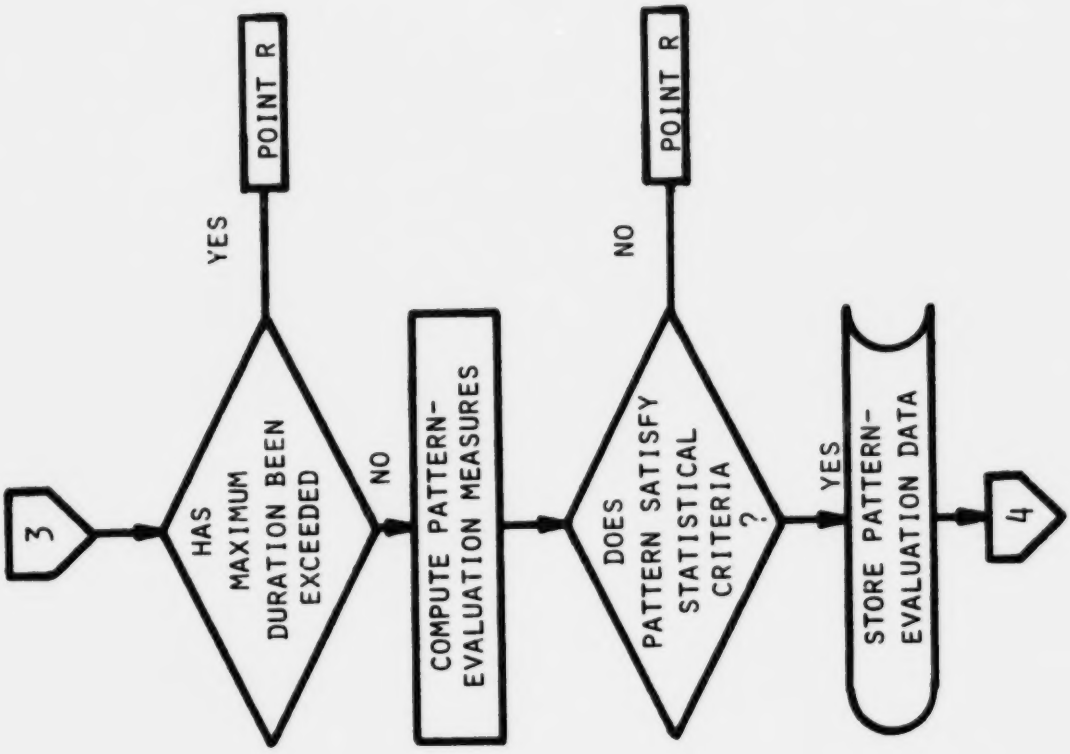

FIGURE 2-7 (CONT'D)

SRL 2148 07 0274

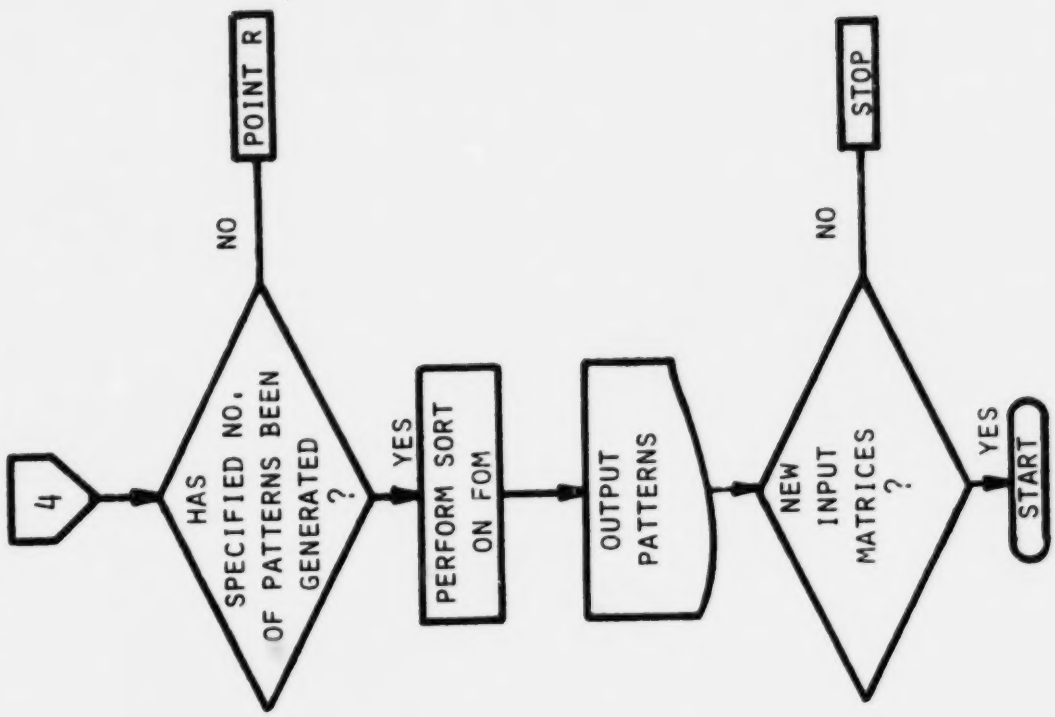

FIGURE 2-7 (CONT'D)

TABLE 2-1

PATTERN EVALUATION CRITERIA

- CORRELATION COEFFICIENTS
  - ACCELERATION
  - DECELERATION
  - CRUISE
  - OVERALL
  - FIGURE OF MERIT
- G-VALUES
- SUMMARY MEASURES
  - % ACCELERATIONS
  - % DECELERATIONS
  - % CRUISES
  - % IDLES

Since the first goal of this project was to generate patterns which are representative of observed driving habits, the problem of matrix similarity becomes of prime importance. Although it would be ideal to generate a pattern which, for example, has a normalized time-in-mode matrix which was identical to that of the corresponding input matrix, it is not possible to do so because of the short pattern duration relative to the large amount of time reflected in the input matrices. I.e., the pattern contains relatively few modes (approximately six to seven per minute of duration). The problem thus becomes one of judging the degree to which a pattern matrix is similar to (or different from) an input matrix.

Since the problem in one sense is that of comparing two sets of numbers to determine how close the numbers are in magnitude, it is natural to consider the set of statistical techniques generally used to make comparisons, to do significance testing, or to establish relationships between variables. An attractive feature of statistical tests is the provision of criterion levels which permit the acceptance or rejection of hypotheses at any desired confidence level. For these reasons, it was first decided to apply the G-test as a matrix-comparison technique. G is a log likelihood ratio test which provides a measure of the deviations of observed numbers from expected numbers; i.e., those numbers specified by the hypothesis of interest. The usual hypothesis to be tested by G is the null hypothesis, or the hypothesis that some set of observed values does not differ from a corresponding set of expected values.

Acceptance or rejection of the null hypothesis (i.e., that the matrices are not significantly different) with the G-test is referenced to a criterion level depending only on the number of degrees of freedom and the selected confidence level. However, application of the G-test requires that the 169-mode matrix be partitioned into a smaller number of areas in order to satisfy the empirical criterion that each expected frequency of occurrence have a value of at least two or three. It was therefore deemed desirable also to identify measures which would be based on each individual mode.

The correlation coefficient was selected as a measure for making mode-by-mode comparisons. For pattern development purposes, correlation coefficients are computed for the acceleration, deceleration, and cruise modes, and for all modes. Consequently, eight correlation coefficients are computed for each cycle: four for the normalized time-in-mode matrix and four for the normalized mode-frequency-of-occurrence matrix.

Finally, the idle, cruise, acceleration, and deceleration data are summed by category to yield the percent of time spent in each of the four mode types and the percent frequency of occurrency of each of the mode types.

A figure of merit was then defined which consisted of a linear combination of the eight correlation coefficients, each subtracted from unity. I.E., the smaller the value of the figure of merit, the more representative the pattern. The statistical data for each pattern meeting the desired criteria were computer-sorted and output in ascending order of figure of merit. The average speed in mph, correlation coefficients, and figure of merit for each of the 88 selected patterns are shown in Table 2-2.

TABLE 2-2

DRIVING PATTERN STATISTICS

AVERAGE SPEED	FREQUENCY MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	TIME MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	FOM
15.38	.869	.844	.764	.912	.929	.865	.902	.933	6.69
15.80	.901	.756	.838	.919	.935	.862	.889	.931	6.41
15.89	.918	.808	.860	.927	.946	.866	.855	.937	5.75
15.97	.917	.809	.802	.930	.936	.836	.821	.932	6.51
15.98	.914	.882	.885	.938	.953	.888	.894	.949	4.72
19.13	.959	.883	.862	.958	.987	.919	.892	.979	3.39
20.66	.985	.822	.840	.966	.991	.880	.890	.980	3.62
19.04	.967	.827	.898	.965	.987	.891	.867	.975	3.65
19.35	.951	.853	.848	.952	.990	.914	.897	.979	3.72
18.89	.987	.847	.857	.968	.987	.842	.867	.976	3.75
18.66	.967	.856	.854	.958	.982	.842	.902	.974	3.92
18.05	.966	.844	.884	.962	.970	.843	.914	.960	3.98
18.61	.969	.832	.845	.959	.984	.829	.918	.972	4.05
19.20	.986	.801	.833	.965	.974	.868	.888	.963	4.16

TABLE 2-2 (CONT'D)

DRIVING PATTERN STATISTICS

AVERAGE SPEED	FREQUENCY MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	TIME MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	FOM
20.22	.961	.826	.849	.960	.991	.860	.847	.979	4.18
18.60	.963	.857	.859	.959	.980	.860	.899	.974	3.87
19.67	.984	.841	.863	.970	.980	.838	.867	.972	3.89
18.80	.943	.869	.829	.948	.989	.888	.904	.978	3.97
19.46	.989	.821	.841	.966	.983	.828	.903	.967	3.98
20.50	.975	.823	.8	.959	.982	.865	.887	.973	4.11
18.72	.975	.889	.91	.973	.982	.912	.938	.978	2.67
19.27	.981	.892	.879	.971	.982	.922	.935	.977	2.75
20.29	.986	.846	.887	.975	.997	.867	.942	.987	2.84
18.96	.979	.881	.884	.973	.985	.921	.913	.978	2.85
19.02	.968	.886	.916	.972	.978	.900	.919	.974	2.99
18.63	.989	.863	.883	.972	.985	.888	.930	.977	2.94
18.87	.968	.877	.853	.965	.986	.947	.911	.980	3.08
20.32	.981	.871	.844	.969	.995	.937	.871	.984	3.09

TABLE 2-2 (CONT'D)

DRIVING PATTERN STATISTICS

AVERAGE SPEED	FREQUENCY MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	TIME MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	FOM
20.37	.982	.878	.849	.968	.993	.907	.891	.979	3.15
20.84	.986	.845	.880	.975	.997	.834	.915	.986	3.18
22.98	.977	.899	.882	.969	.976	.895	.917	.968	3.13
22.23	.976	.875	.888	.973	.962	.888	.925	.965	3.36
23.47	.981	.885	.876	.974	.958	.905	.874	.968	3.48
24.15	.974	.854	.857	.967	.984	.883	.898	.978	3.50
24.95	.983	.848	.863	.976	.967	.859	.921	.972	3.57
23.56	.989	.845	.838	.972	.983	.882	.877	.975	3.60
23.47	.963	.886	.890	.970	.958	.850	.937	.967	3.61
22.77	.965	.870	.859	.969	.975	.871	.919	.970	3.61
23.83	.972	.859	.852	.973	.974	.845	.923	.977	3.64
25.45	.984	.859	.824	.973	.986	.845	.893	.979	3.67
22.67	.963	.861	.876	.966	.964	.898	.909	.968	3.67
20.92	.963	.895	.897	.965	.946	.893	.932	.950	3.67

TABLE 2-2 (CONT'D)

DRIVING PATTERN STATISTICS

AVERAGE SPEED	FREQUENCY MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	TIME MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	FOM
24.64	.993	.826	.850	.976	.989	.874	.832	.981	3.71
28.15	.976	.851	.834	.970	.981	.851	.901	.979	3.76
27.70	.967	.853	.863	.973	.978	.847	.873	.981	3.82
28.43	.968	.838	.823	.959	.986	.860	.888	.978	4.05
30.04	.961	.835	.856	.971	.987	.871	.823	.983	4.05
30.62	.963	.850	.848	.973	.973	.864	.841	.980	4.09
27.25	.940	.846	.843	.957	.977	.893	.898	.972	4.14
29.58	.964	.832	.816	.960	.984	.857	.886	.982	4.15
28.40	.954	.870	.851	.964	.980	.824	.879	.974	4.16
27.28	.965	.853	.843	.973	.959	.836	.893	.974	4.16
26.11	.966	.842	.851	.964	.950	.872	.894	.972	4.20
27.52	.955	.865	.844	.964	.976	.879	.822	.979	4.21
28.33	.950	.818	.869	.970	.968	.866	.862	.977	4.28
27.16	.958	.864	.825	.966	.972	.827	.884	.974	4.30

TABLE 2-2 (CONT'D)

DRIVING PATTERN STATISTICS

AVERAGE SPEED	FREQUENCY MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	TIME MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	FOM
32.99	.942	.859	.845	.967	.992	.866	.844	.989	4.04
30.66	.962	.829	.893	.969	.956	.818	.861	.973	4.40
32.12	.929	.839	.848	.967	.982	.803	.822	.987	4.80
30.80	.968	.832	.845	.968	.937	.807	.876	.963	4.84
31.95	.905	.859	.846	.959	.974	.842	.807	.983	5.03
33.71	.915	.809	.804	.963	.986	.812	.864	.987	5.04
31.00	.965	.830	.831	.966	.951	.819	.808	.969	5.05
31.10	.916	.844	.820	.958	.961	.807	.873	.974	5.20
31.52	.920	.873	.821	.965	.951	.846	.802	.971	5.22
31.00	.909	.810	.833	.958	.964	.808	.865	.975	5.36
30.66	.949	.804	.802	.961	.948	.839	.807	.967	5.48
29.66	.911	.866	.824	.962	.913	.874	.803	.953	5.77
41.88	.940	.925	.940	.980	.997	.836	.848	.994	3.15
43.26	.907	.951	.898	.976	.995	.893	.852	.994	3.30

TABLE 2-2 (CONT'D)

DRIVING PATTERN STATISTICS

AVERAGE SPEED	FREQUENCY MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	TIME MATRIX CORRELATIONS CRUISE	ACCEL	DECEL	TOTAL	FOM
41.98	.934	.916	.926	.972	.994	.806	.883	.992	3.42
44.14	.934	.887	.923	.969	.998	.823	.836	.996	3.68
43.20	.952	.856	.898	.957	.986	.839	.832	.987	4.05
42.50	.920	.869	.893	.970	.998	.814	.823	.996	4.17
42.43	.938	.882	.889	.963	.990	.811	.801	.990	4.28
44.61	.936	.883	.863	.944	.995	.819	.814	.993	4.43
45.46	.904	.891	.890	.941	.998	.804	.841	.994	4.51
44.07	.921	.855	.865	.949	.994	.823	.803	.993	4.69
41.63	.923	.938	.958	.979	.999	.861	.930	.997	2.59
44.01	.973	.913	.893	.965	.998	.861	.848	.996	3.11
42.99	.944	.922	.909	.977	.998	.840	.861	.997	3.18
41.76	.919	.934	.933	.975	.998	.880	.838	.995	3.21
43.41	.947	.907	.909	.973	.997	.811	.869	.996	3.39
43.71	.939	.914	.884	.964	.999	.866	.811	.997	3.65

TABLE 2-2 (CONT'D)

DRIVING PATTERN STATISTICS

AVERAGE SPEED	FREQUENCY MATRIX CORRELATIONS				TIME MATRIX CORRELATIONS				
	CRUISE	ACCEL	DECEL	TOTAL	CRUISE	ACCEL	DECEL	TOTAL	FOM
43.50	.949	.903	.882	.965	.997	.819	.829	.996	3.76
44.25	.904	.910	.918	.968	.997	.810	.862	.996	3.86
42.07	.918	.916	.914	.971	.996	.810	.812	.994	3.95
41.21	.933	.871	.904	.973	.995	.807	.847	.990	3.95

3.0 EMISSIONS ESTIMATIONS

After selection of the 88 most representative driving patterns at the various average route speeds, the EPA-supplied computer program was utilized to estimate the emissions over each pattern for each vehicle group. The driving pattern generation computer program was modified by computing and storing speed data on a second-by-second basis and incorporating the EPA-supplied program. The emissions and average speed for each pattern and vehicle group combination were then output on punched cards. An overview of the process is shown in the flow diagram of Figure 3-1. The vehicle groups for which emissions were estimated are defined in Table 3-1. Tables A-1 through A-11 of Appendix A give the emissions and average speed for each of the 88 patterns by vehicle group. The emissions are given in units of both grams per kilometer (gpk) and grams per mile (gpm), while the average speeds are in mph. A multiple step-wise regression analysis was then conducted with those data. The results of that analysis are presented in the next section.

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CYCCRUD PROGRAM

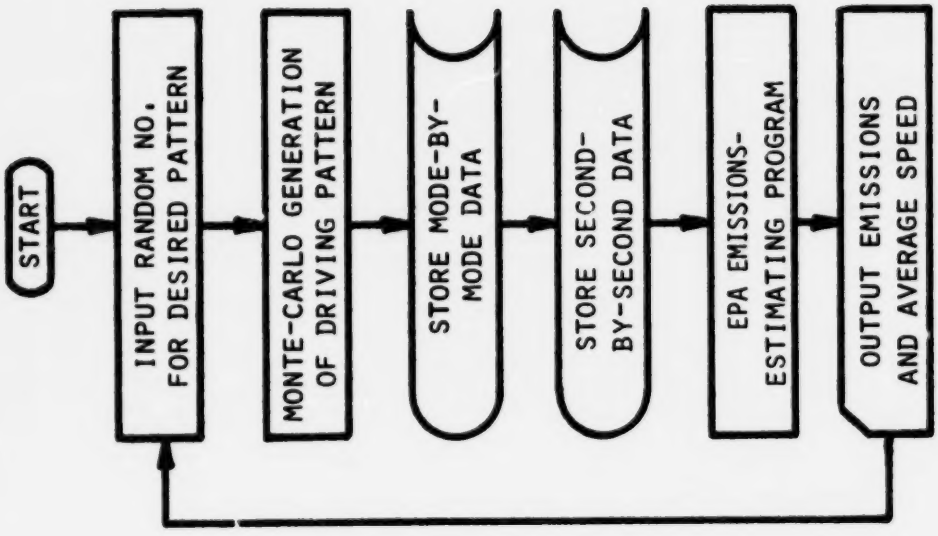

FIGURE 3-1

TABLE 3-1

VEHICLE GROUP DEFINITIONS

GROUP NUMBER	MODEL YEARS	GEOGRAPHICAL DESIGNATION
1	1957-1967	DENVER
2	1957-1967	LOW ALTITUDE (EXCL. '66-'67 CALIF.)
3	1966-1967	CALIFORNIA
4	1968	LOW ALTITUDE
5	1969	LOW ALTITUDE
6	1970	LOW ALTITUDE
7	1971	LOW ALTITUDE
8	1968	DENVER
9	1969	DENVER
10	1970	DENVER
11	1971	DENVER

4.0 RESULTS

The end product of the procedures described above is a set of regression equations from which one may compute each of the three emission types for each vehicle group. The natural logarithms of the HC and CO are computed from quadratic functions of the average route speed, denoted by $\overline{S}$, and the NO_x values are computed from linear functions of $\overline{S}$. To facilitate comparison of the curve shapes for each emission and vehicle group combination, curves of emissions versus average route speed were normalized to the emissions at $\overline{S}$ = 31.5 kph (19.6 mph), the average speed over the Federal driving schedule.

The normalizing values for each emission by vehicle group are given in Tables 4-1 and 4-2. The normalized speed correction curves of emissions versus $\overline{S}$ for each vehicle group are given in Figures 4-1 through 4-11. To determine the value of an emission at any given speed from 24 to 72 kph (15 to 45 mph), first determine from the curve for the vehicle group of interest the value of the speed correction factor at the desired speed. Then multiply the corresponding emission value in Table 4-1 (or Table 4-2, for grams per mile) by the speed correction factor to obtain the emission value in the desired units.

The regression equations which relate emissions to average route speed by vehicle group are given in Tables 4-3, 4-4, and 4-5. In addition to the regression equations, those tables give for each equation the multiple correlation coefficient, R, its square in units of percent, and the standard error of the estimate. Note that R^2, the coefficient of determination, yields the percent of the data variance which is accounted for by the regression relationship. The standard error of the estimate is a measure of how well the equation estimates the emissions.

In the case of the HC and CO, since the natural logarithms of those emissions were used as the dependent variables, multiplying the listed standard errors of the estimate by 100 yields the error estimate as a percentage. The standard errors of the estimate for the NO_x are in units of grams/mile. Note that the conversion of emissions to units of grams/kilometer is easily accomplished by multiplying the gms/mile value by 0.62137 (or dividing by 1.6093).

Examination of Tables 4-3 and 4-4 indicates that the regression relationships for HC and CO provide excellent fits to the input data. The regression relationships in Table 4-5 indicate that the NO_x data fits are acceptable, although not as good as those for the HC and CO.

TABLE 4-1

EMISSION VALUES AT AN AVERAGE ROUTE SPEED OF 31.5 KPH

VEHICLE GROUP	HC (GMS/KILOM.)	CO (GMS/KILOM.)	NO_x (GMS/KILOM.)
1	5.44	83.33	1.42
2	4.74	49.02	2.44
3	3.42	30.72	2.32
4	3.18	40.44	2.97
5	2.90	32.17	3.96
6	2.19	26.28	3.63
7	1.87	27.11	3.31
8	3.46	71.28	1.60
9	2.67	50.89	1.85
10	3.28	64.23	2.02
11	2.86	65.57	2.08

TABLE 4-2

EMISSION VALUES AT AN AVERAGE ROUTE SPEED OF 19.6 MPH

VEHICLE GROUP	HC (GMS/MILE)	CO (GMS/MILE)	NO_x (GMS/MILE)
1	8.76	134.11	2.28
2	7.62	78.89	3.93
3	5.50	49.44	3.74
4	5.12	65.08	4.78
5	4.67	51.78	6.38
6	3.53	42.30	5.85
7	3.01	43.63	5.33
8	5.57	114.71	2.57
9	4.30	81.90	2.97
10	5.28	103.36	3.24
11	4.60	105.53	3.34

TABLE 4-3

REGRESSION EQUATIONS OF THE FORM LN HC = A + B $\bar{S}$ + C$\bar{S}^2$
(IN UNITS OF GRAMS PER MILE)

VEH. GRP.	A	B	C	MULT. R	R^2 (%)	STD. ERR. OF EST.
1	3.05297	-5.58319×10^{-2}	5.51585×10^{-4}	0.9974	99.5	0.0154
2	2.98338	-5.99767×10^{-2}	5.80943×10^{-4}	0.9980	99.6	0.0147
3	2.66145	-5.98232×10^{-2}	5.63255×10^{-4}	0.9992	99.8	0.0099
4	2.70316	-6.63011×10^{-2}	5.98211×10^{-4}	0.9988	99.8	0.0137
5	2.54636	-6.26878×10^{-2}	5.79923×10^{-4}	0.9985	99.7	0.0144
6	2.16247	-5.69535×10^{-2}	5.58732×10^{-4}	0.9976	99.5	0.0152
7	2.04527	-5.92347×10^{-2}	5.67343×10^{-4}	0.9979	99.6	0.0152
8	2.43936	-4.62533×10^{-2}	4.79837×10^{-4}	0.9948	99.0	0.0167
9	2.16433	-4.54768×10^{-2}	4.84409×10^{-4}	0.9948	99.0	0.0156
10	2.50366	-5.32822×10^{-2}	5.33325×10^{-4}	0.9969	99.4	0.0157
11	2.31339	-4.98932×10^{-2}	4.99244×10^{-4}	0.9952	99.0	0.0181

Table 4-4

Regression Equations of The Form $\ln CO = A + B\bar{S} + C\bar{S}^2$
(In units of grams per mile)

Veh. Grp.	A	B	C	Multi. R	R^2 (%)	Std. Err. of Est.
1	5.61991	-4.57276×10^{-2}	4.55637×10^{-4}	0.9943	98.9	0.0184
2	5.33475	-6.06584×10^{-2}	5.78421×10^{-4}	0.9980	99.6	0.0152
3	4.88181	-6.21854×10^{-2}	6.18978×10^{-4}	0.9978	99.6	0.0155
4	5.22263	-6.51947×10^{-2}	6.00899×10^{-4}	0.9985	99.7	0.0148
5	5.20578	-7.71552×10^{-2}	6.59770×10^{-4}	0.9989	99.8	0.0161
6	5.01179	-7.71946×10^{-2}	6.40350×10^{-4}	0.9987	99.7	0.0185
7	5.01669	-7.52438×10^{-2}	6.08591×10^{-4}	0.9985	99.7	0.0198
8	5.40456	-4.22728×10^{-2}	4.33105×10^{-4}	0.9877	97.6	0.0239
9	5.03307	-4.03763×10^{-2}	4.26267×10^{-4}	0.9763	95.3	0.0305
10	5.47334	-5.23697×10^{-2}	4.98092×10^{-4}	0.9917	98.3	0.0270
11	5.55310	-5.54041×10^{-2}	4.99253×10^{-4}	0.9922	98.4	0.0298

TABLE 4-5

REGRESSION EQUATIONS OF THE FORM $NO_x = A + B\bar{S}$
(IN UNITS OF GRAMS PER MILE)

VEH. GRP.	A	B	MULT. R	R^2 (%)	STD.ERR. OF EST.
1	1.37325	4.62134×10^{-2}	0.9751	95.1	0.0992
2	3.17413	3.85334×10^{-2}	0.9547	91.1	0.1134
3	3.15629	2.98311×10^{-2}	0.9351	87.4	0.1067
4	4.24644	2.71939×10^{-2}	0.9082	82.5	0.1183
5	5.83611	2.75849×10^{-2}	0.8616	74.2	0.1534
6	4.93157	4.66796×10^{-2}	0.9393	88.2	0.1611
7	4.49361	4.28722×10^{-2}	0.9401	88.4	0.1468
8	1.65072	4.71563×10^{-2}	0.9755	95.2	0.1003
9	2.15763	4.16635×10^{-2}	0.9699	94.1	0.0987
10	1.98983	6.40748×10^{-2}	0.9754	95.1	0.1367
11	2.32847	5.18718×10^{-2}	0.9721	94.5	0.1182

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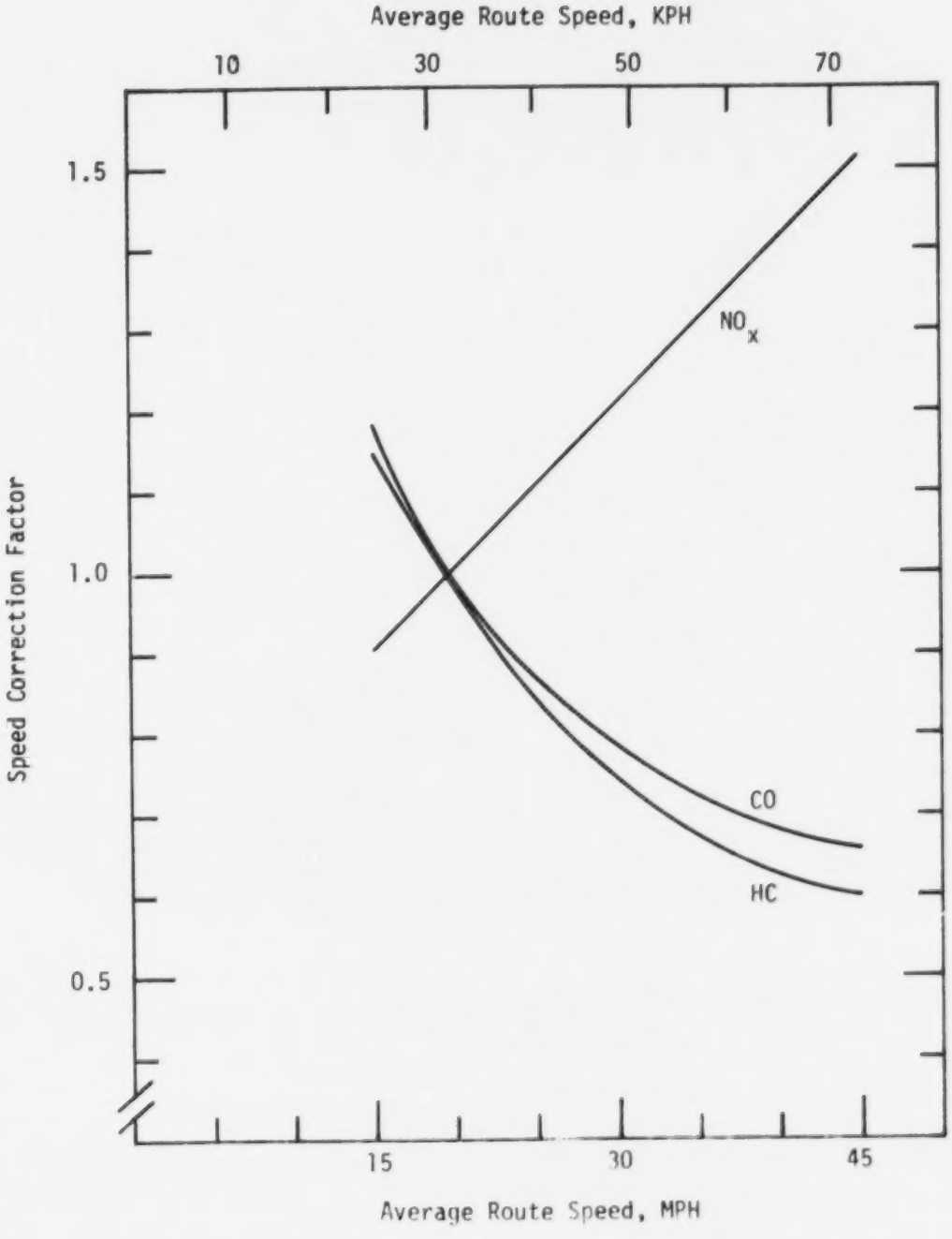

Figure 4-1 Speed Correction Factors for Group 1 Vehicles

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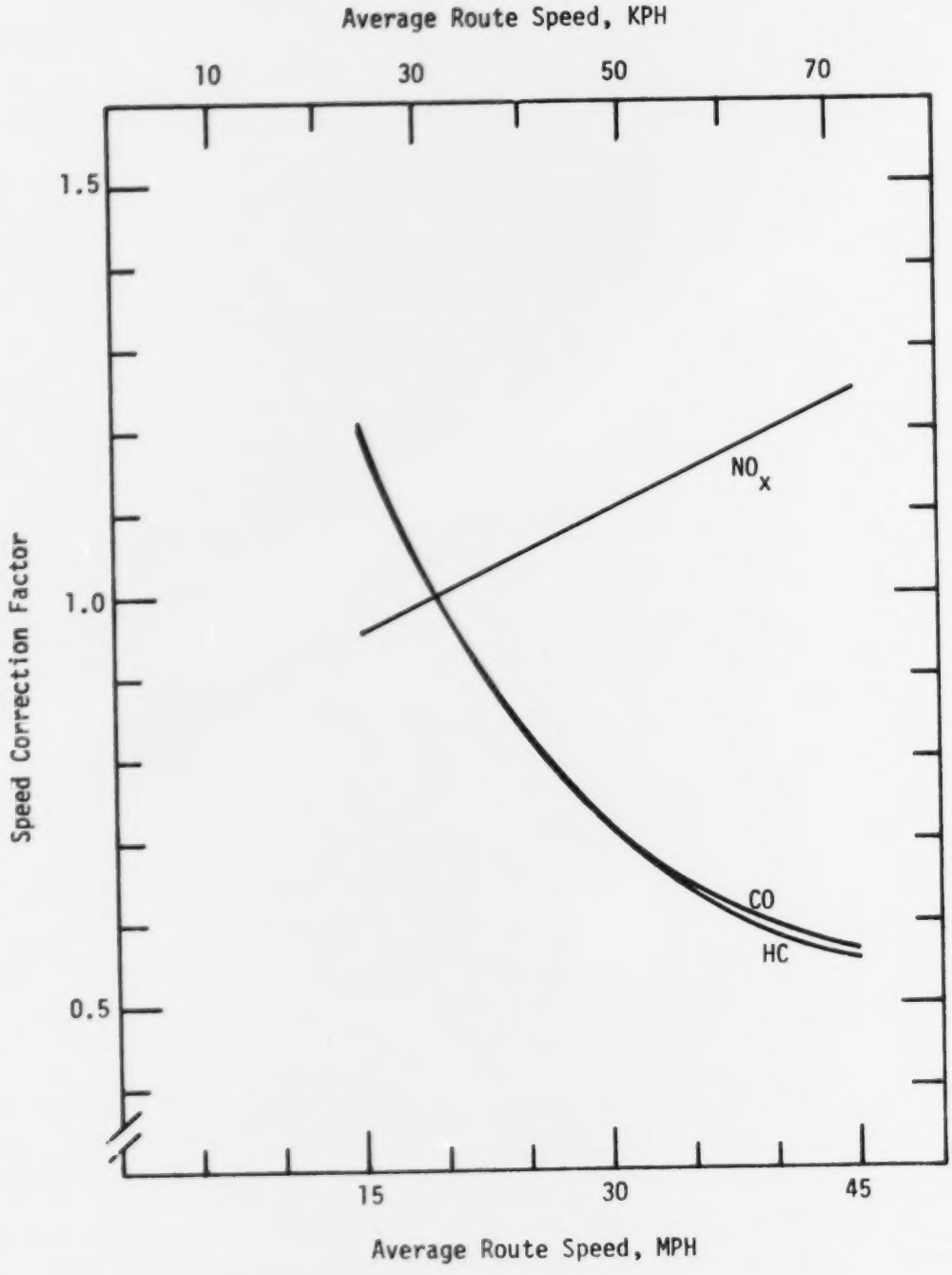

Figure 4-2 Speed Correction Factors for Group 2 Vehicles

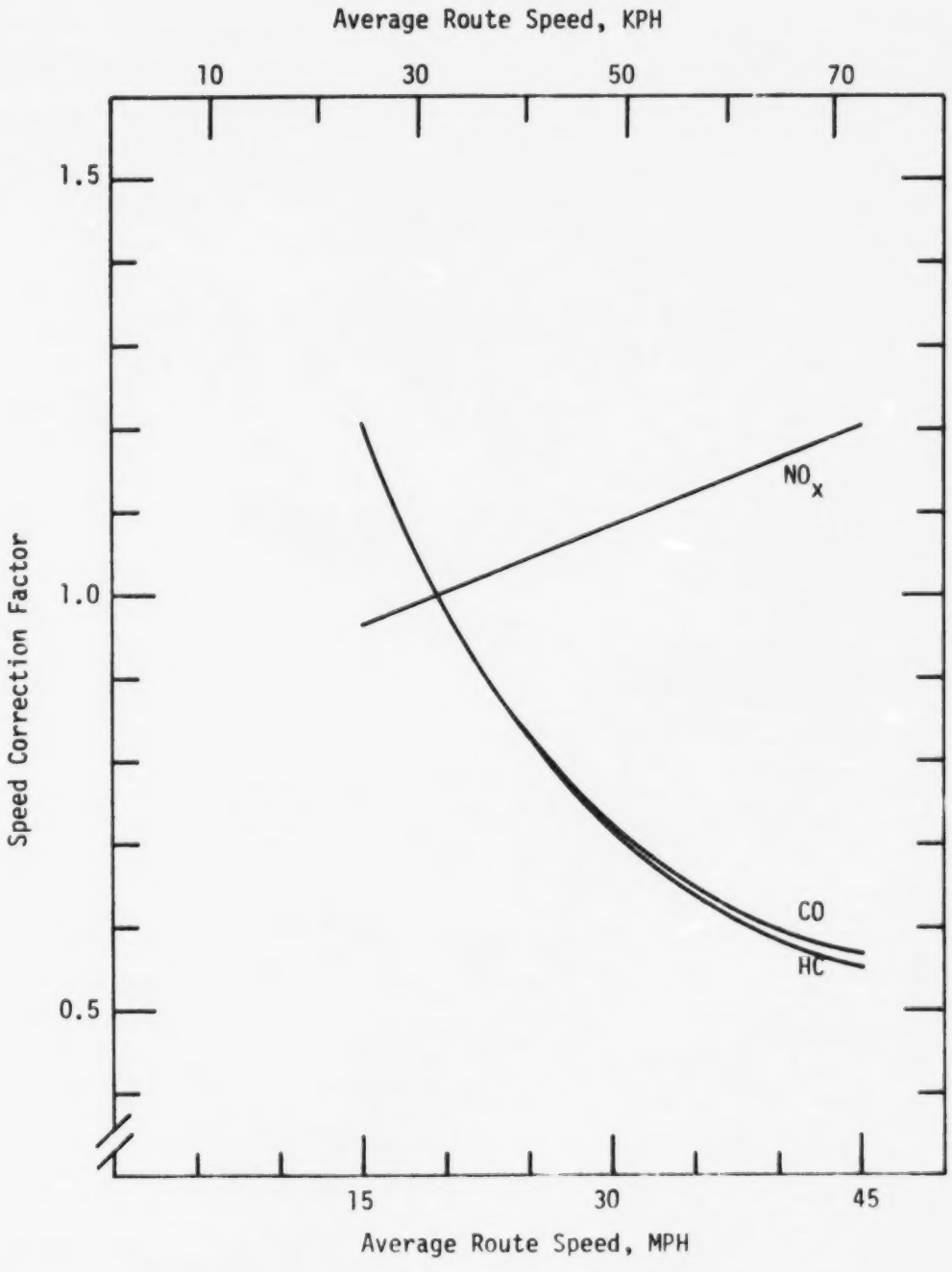

Figure 4-3 Speed Correction Factors for Group 3 Vehicles

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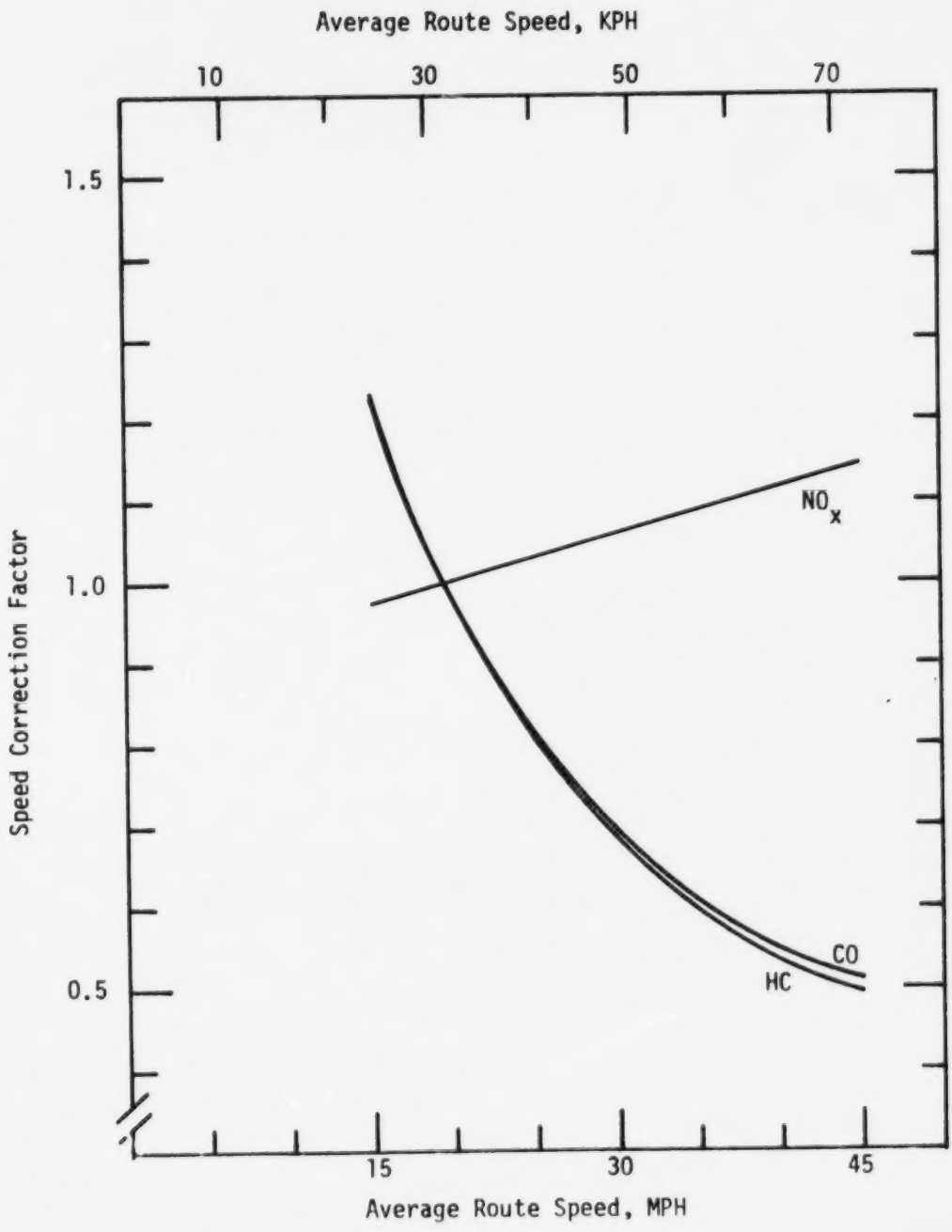

Figure 4-4 Speed Correction Factors for Group 4 Vehicles

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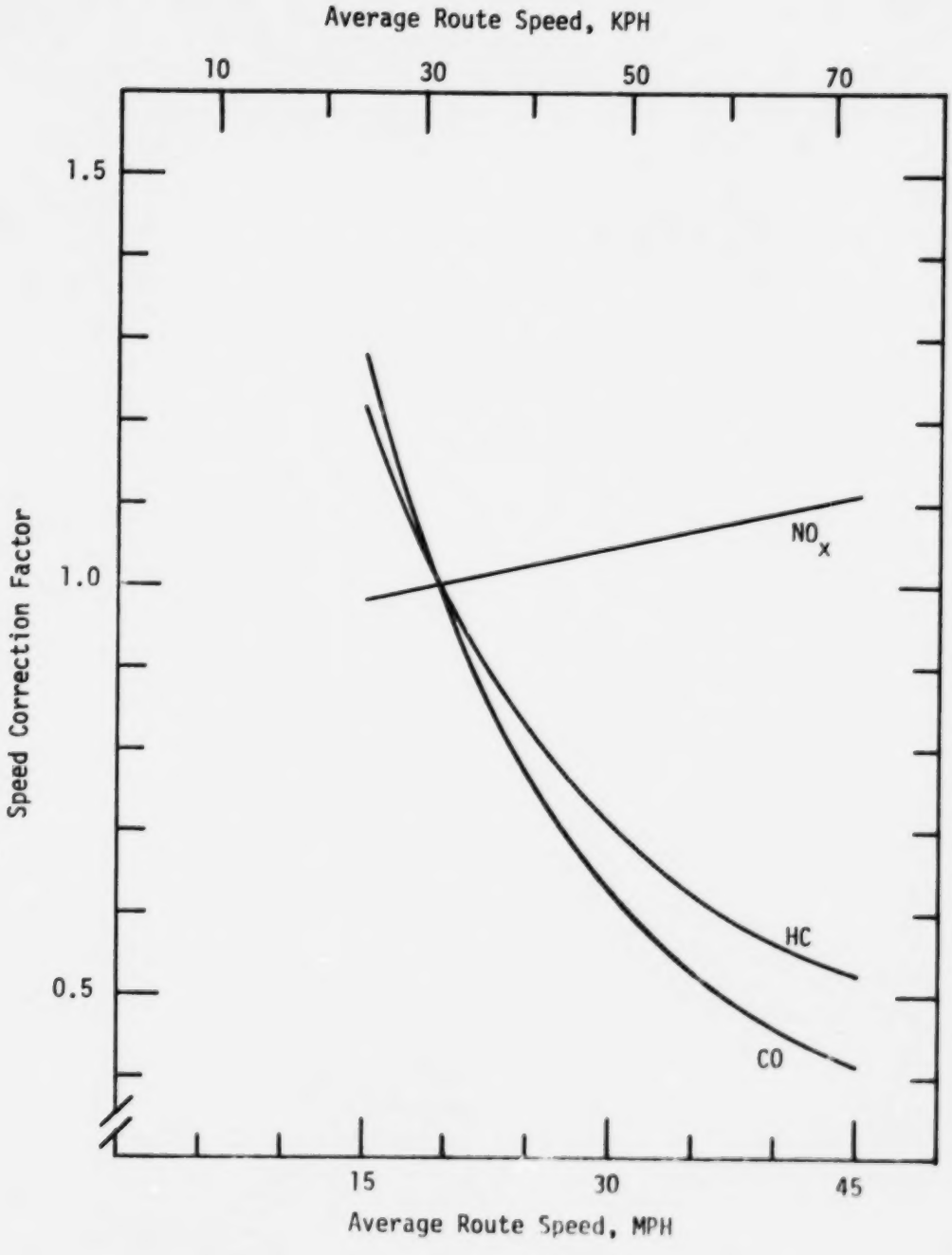

Figure 4-5 Speed Correction Factors for Group 5 Vehicles

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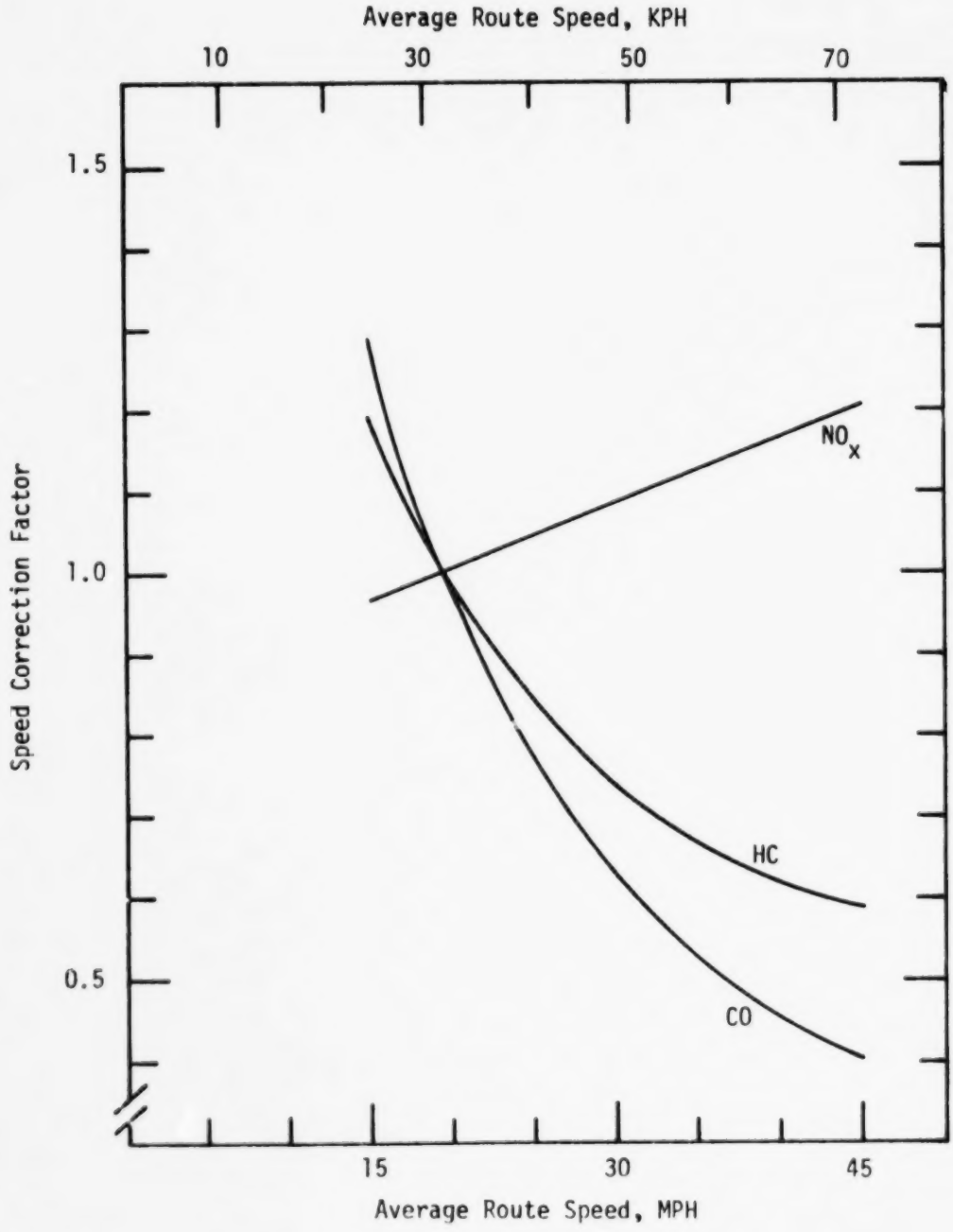

Figure 4-6 Speed Correction Factors for Group 6 Vehicles

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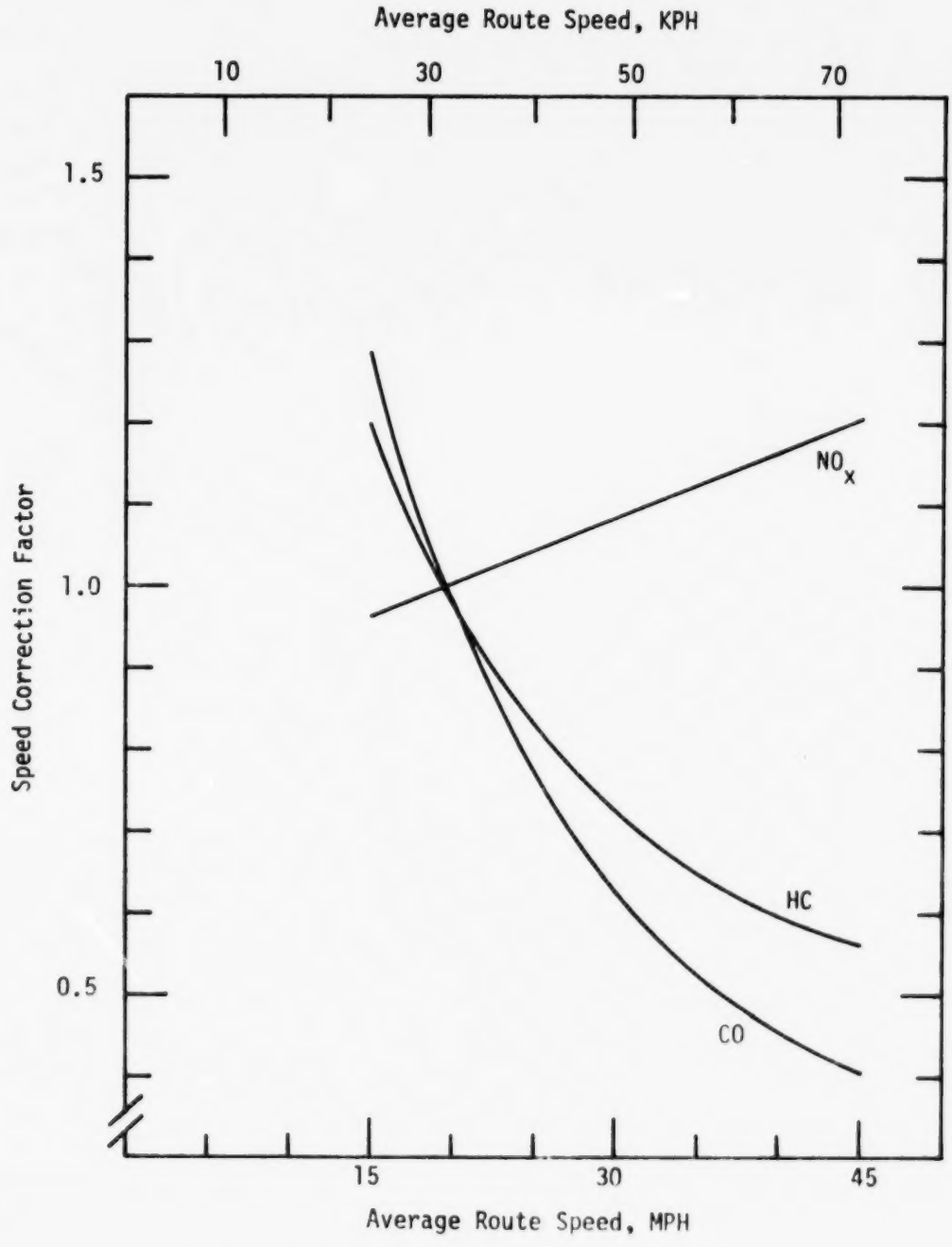

Figure 4-7 Speed Correction Factors for Group 7 Vehicles

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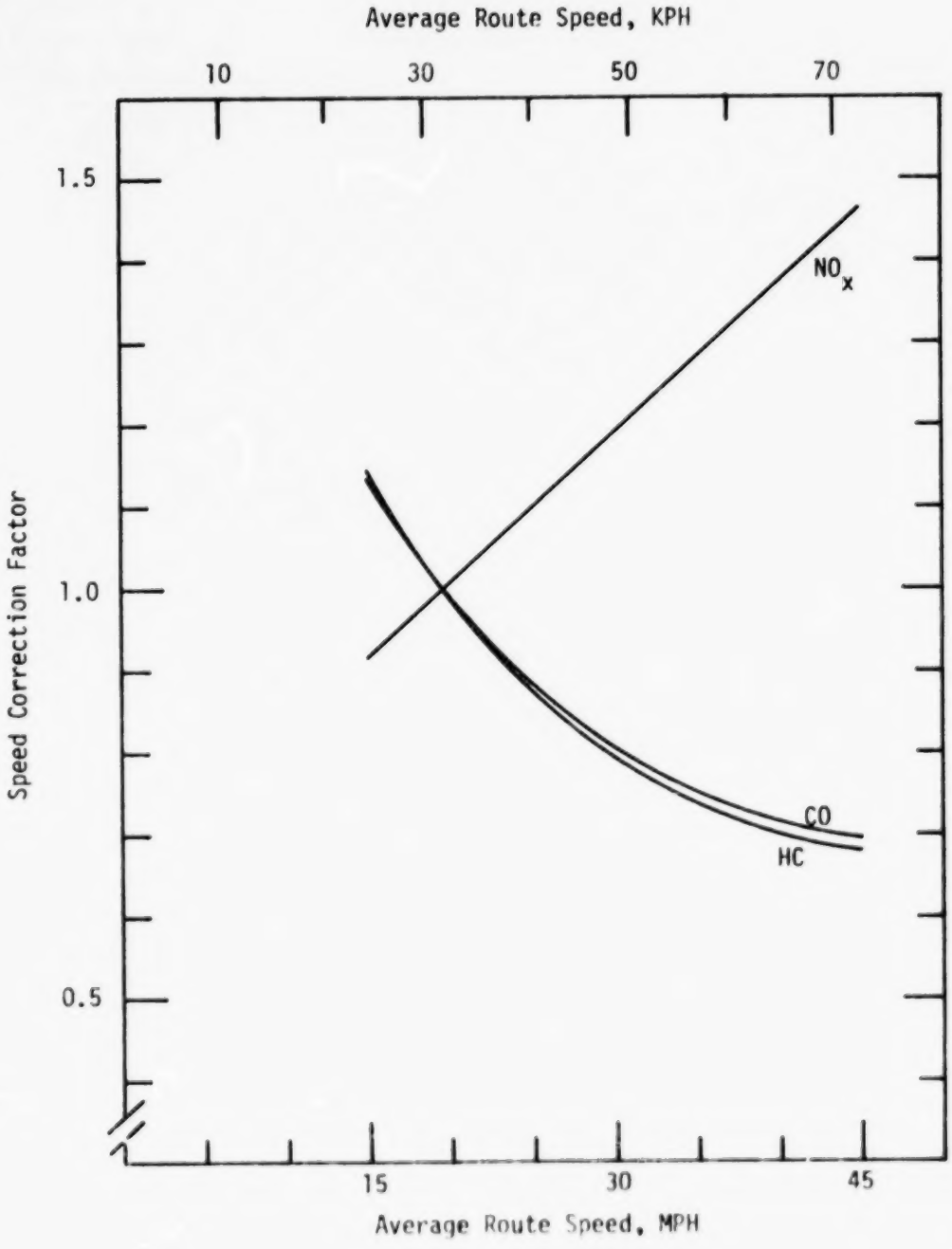

Figure 4-8 Speed Correction Factors for Group 8 Vehicles

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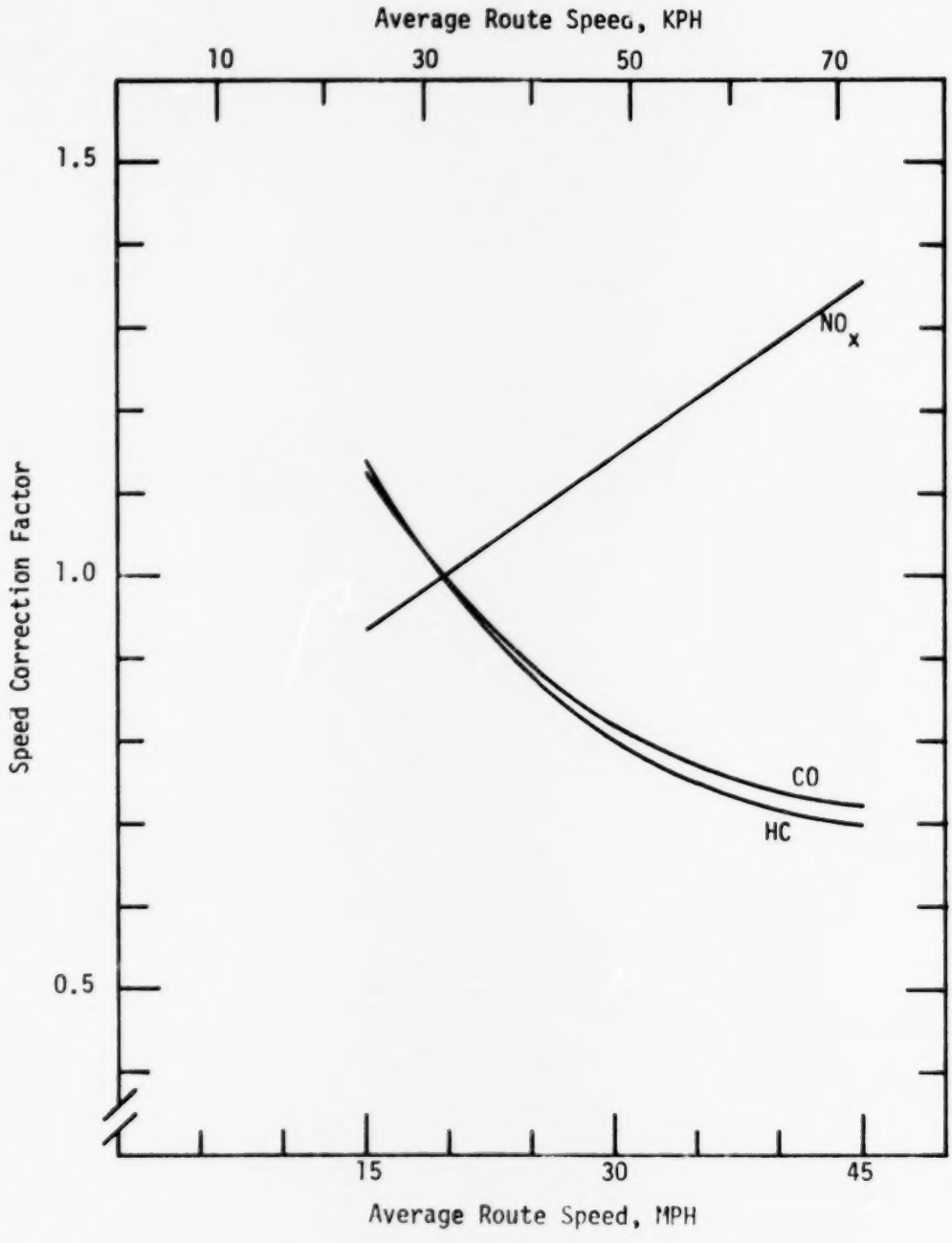

Figure 4-9 Speed Correction Factors for Group 9 Vehicles

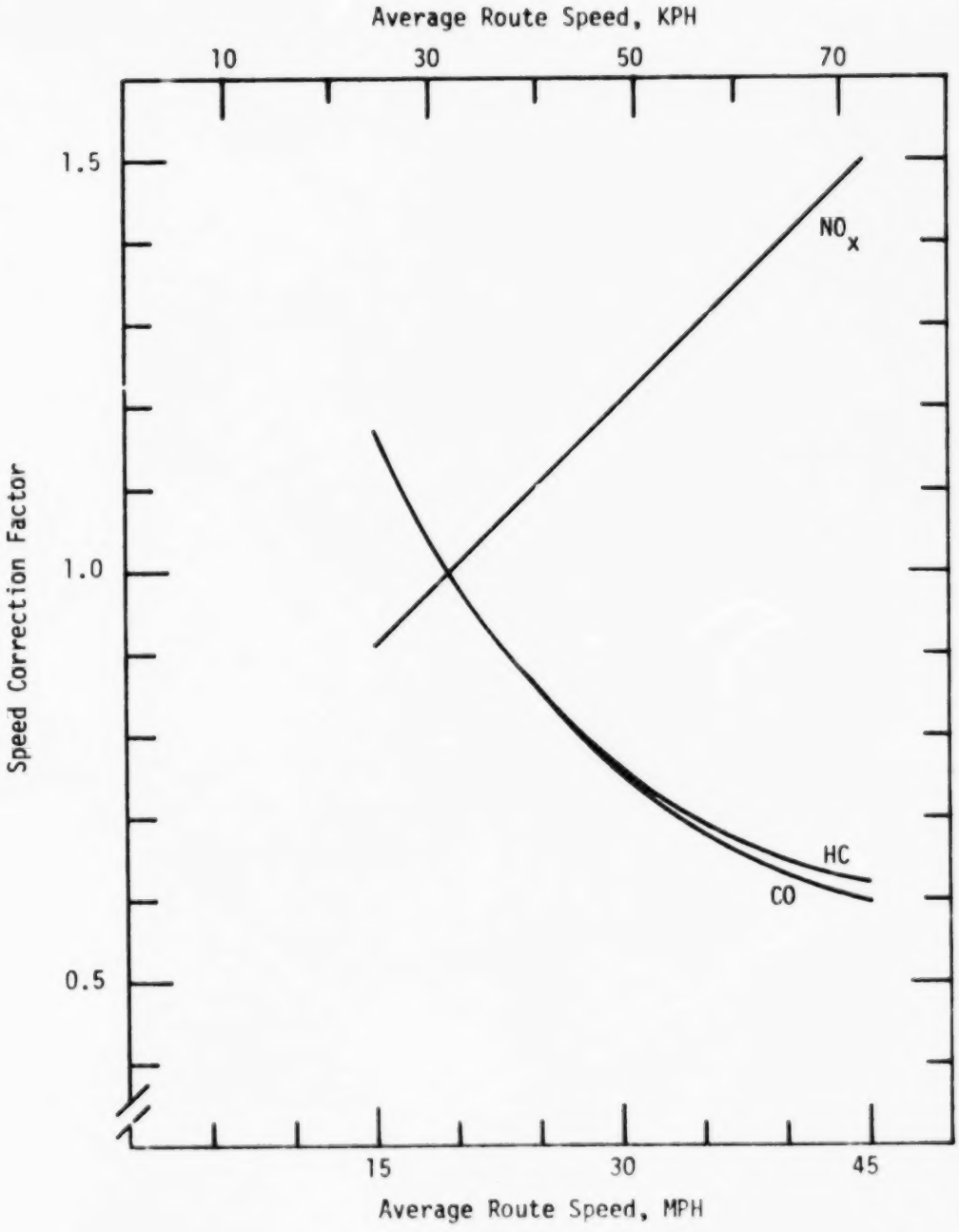

Figure 4-10 Speed Correction Factors for Group 10 Vehicles

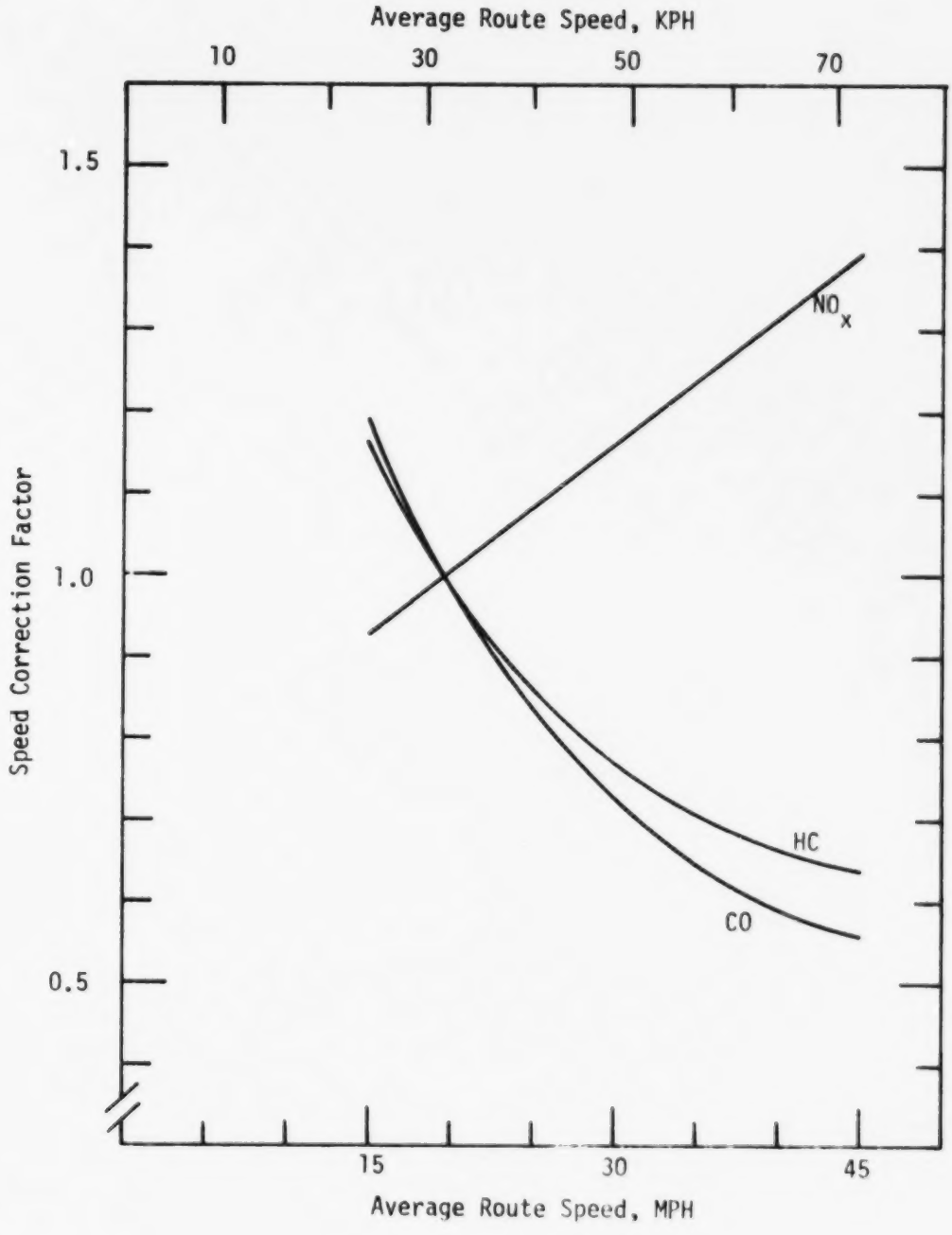

Figure 4-11 Speed Correction Factors for Group 11 Vehicles

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APPENDIX A

Tables A-1 through A-11 show the computed emissions over each of the 88 driving patterns by vehicle group in units of grams per kilometer (gpk) and grams per mile (gpm). The average speeds are in units of miles per hour (mph).

TABLE A- 1

ESTIMATED GROUP I EMISSIONS

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AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPM)	CO (GPM)	NOX (GPM)
15.36	0.62	97.95	1.34	10.06	157.63	2.16
15.80	0.47	96.16	1.35	10.42	154.75	2.17
15.89	0.50	95.92	1.37	10.46	155.93	2.21
15.97	0.25	92.59	1.34	10.37	149.01	2.15
15.98	0.36	94.40	1.35	10.24	151.92	2.17
19.13	0.39	81.74	1.38	9.63	131.55	2.22
20.66	0.22	80.74	1.35	9.41	129.94	2.17
19.04	0.57	85.24	1.35	9.97	137.15	2.17
19.35	0.47	83.34	1.34	9.80	134.12	2.16
18.89	0.45	82.15	1.31	9.77	132.23	2.11
18.66	0.54	84.34	1.35	9.92	135.61	2.18
18.05	0.76	87.85	1.35	9.80	141.38	2.18
18.01	0.52	83.70	1.35	9.71	135.12	2.18
19.23	0.54	85.23	1.36	9.91	137.04	2.19
20.22	0.34	81.44	1.36	9.54	131.36	2.19
18.83	0.53	83.35	1.36	9.90	133.11	2.19
19.07	0.29	79.07	1.33	9.45	128.71	2.16
18.80	0.62	85.44	1.34	9.84	137.51	2.16
19.46	0.52	85.39	1.34	9.88	137.43	2.16
20.50	0.18	80.15	1.33	9.34	129.06	2.13
18.72	0.54	86.37	1.34	9.98	138.99	2.16
19.27	0.35	81.34	1.37	9.62	130.91	2.20
20.24	0.33	82.57	1.36	9.58	132.27	2.1
18.96	0.50	85.14	1.35	9.95	136.67	2.19
19.03	0.24	84.26	1.36	9.91	135.61	2.19
18.83	0.56	86.62	1.34	9.10	139.40	2.15
18.81	0.03	86.53	1.35	9.09	139.26	2.18
20.32	0.30	83.40	1.36	9.61	134.21	2.18
20.37	0.26	81.75	1.35	9.49	131.03	2.17
23.89	0.08	77.13	1.37	8.14	124.07	2.21

TABLE A- 1 (CONTINUED)

ESTIMATED GROUP 1 EMISSIONS

AVERAGE SPEED	HC (GPM)	CO (GPM)	NOX (GPM)	HC (GPM)	CO (GPM)	NOX (GPM)
22.98	4.86	75.94	1.61	7.43	122.22	2.55
22.23	4.94	76.53	1.56	7.56	123.16	2.41
23.47	4.65	72.54	1.49	7.46	119.75	2.39
24.15	4.68	73.02	1.57	7.53	117.51	2.53
24.55	4.75	76.59	1.57	7.64	123.26	2.52
23.56	4.78	73.14	1.56	7.56	117.73	2.51
23.47	4.74	74.25	1.59	7.63	119.47	2.54
22.11	4.98	75.28	1.53	8.31	125.99	2.47
23.83	4.70	73.37	1.52	7.56	115.07	2.45
25.45	4.66	74.02	1.64	7.41	119.12	2.62
22.67	4.71	74.36	1.56	7.72	119.70	2.41
20.92	5.13	79.78	1.56	8.34	125.97	2.53
24.64	4.58	72.14	1.54	7.37	115.25	2.47
26.15	4.29	68.11	1.75	6.93	109.32	2.79
27.76	4.36	69.80	1.71	7.01	112.53	2.75
28.93	4.15	66.28	1.76	6.68	106.67	2.83
30.64	4.09	66.13	1.80	6.59	106.43	2.90
30.62	4.02	65.39	1.80	6.47	104.75	2.89
27.25	4.42	71.10	1.75	7.11	114.42	2.81
29.25	4.08	65.34	1.77	6.57	105.26	2.85
28.90	4.32	69.14	1.81	6.91	111.27	2.91
27.28	4.32	69.08	1.66	6.96	111.17	2.76
26.11	4.44	70.28	1.68	7.14	113.10	2.71
27.52	4.30	68.64	1.71	6.97	110.15	2.76
28.33	4.30	69.32	1.75	6.92	111.25	2.81
27.16	4.42	70.30	1.74	7.11	113.44	2.80
32.99	3.80	62.90	1.90	6.21	101.22	3.02
31.66	3.97	64.23	1.81	6.39	103.34	2.91
32.12	3.87	62.96	1.85	6.23	101.32	2.97
31.86	3.90	64.38	1.76	6.37	103.57	2.82

[illegible]

TABLE A- 2

ESTIMATED GROUP 2 EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPM)	CO (GPM)	NOX (GPM)
15.30	5.83	60.42	2.40	1.39	91.24	3.67
15.60	5.69	58.91	2.46	1.36	91.81	3.87
15.89	5.70	59.17	2.51	1.38	93.22	4.03
15.97	5.53	57.30	2.40	1.33	92.21	3.96
15.96	5.61	58.11	2.44	1.32	93.52	3.93
19.13	4.71	48.87	2.37	1.29	79.03	3.91
20.66	4.52	46.74	2.35	1.27	79.23	3.93
19.04	4.69	50.10	2.40	1.30	83.15	3.96
19.35	4.76	49.17	2.36	1.30	79.13	3.80
18.89	4.74	49.14	2.29	1.33	79.08	3.68
18.68	4.94	50.41	2.37	1.29	81.12	3.81
18.39	5.04	52.44	2.41	1.42	84.40	3.89
18.81	4.83	50.22	2.36	1.33	80.82	3.80
19.20	4.85	50.14	2.43	1.37	83.67	3.98
20.22	4.60	47.66	2.39	1.41	79.70	3.99
18.80	4.83	50.29	2.36	1.37	80.93	3.90
19.67	4.57	47.25	2.27	1.36	79.38	3.82
18.80	4.89	50.52	2.38	1.37	81.30	3.84
19.46	4.80	49.56	2.42	1.33	77.73	3.79
20.50	4.51	46.75	2.39	1.25	75.25	3.84
18.72	4.91	51.30	2.40	1.30	82.37	3.85
19.27	4.68	48.42	2.35	1.33	77.92	3.79
20.29	4.61	47.80	2.38	1.43	75.93	3.78
18.95	4.85	50.10	2.37	1.31	83.92	3.96
19.02	4.83	49.91	2.39	1.33	80.32	3.84
18.83	4.93	51.12	2.40	1.35	82.27	3.87
18.87	4.92	51.00	2.42	1.31	82.37	3.93
20.23	4.63	48.13	2.41	1.43	77.45	3.91
20.37	4.59	47.34	2.38	1.37	76.17	3.83
20.64	4.45	45.23	2.33	1.38	72.74	3.74

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TABLE 3- [illegible]

ESTIMATED [illegible] EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	[illegible] (GPK)	CO2 (GPK)	[illegible] (GPK)
31.55	3.31	34.12	2.82	5.52	54.51	[illegible]
33.71	3.18	32.33	2.82	5.12	52.36	[illegible]
31.60	3.32	34.35	2.82	5.45	55.79	[illegible]
31.15	3.40	34.92	2.83	5.47	56.21	[illegible]
31.52	3.36	33.32	2.76	5.31	54.43	[illegible]
31.56	3.34	34.14	2.78	5.35	54.93	[illegible]
30.66	3.42	34.98	2.77	5.50	55.80	[illegible]
29.68	3.44	35.28	2.69	5.54	56.75	[illegible]
41.85	2.75	27.35	2.92	4.43	44.45	[illegible]
43.26	2.73	27.64	3.32	4.37	44.51	[illegible]
41.90	2.76	28.03	2.94	4.43	45.11	[illegible]
44.14	2.73	27.76	3.34	4.37	44.71	[illegible]
43.23	2.71	27.31	2.95	[illegible]	44.27	[illegible]
42.50	2.72	27.71	2.96	4.37	44.95	[illegible]
42.43	2.77	26.11	2.91	4.45	45.34	[illegible]
44.61	2.67	27.02	3.32	4.30	43.99	[illegible]
43.46	2.65	25.76	3.05	4.27	43.01	[illegible]
44.07	2.61	27.34	2.95	4.30	43.52	[illegible]
41.64	2.71	26.33	2.96	4.43	43.12	[illegible]
44.01	2.67	27.15	2.78	4.33	43.75	[illegible]
42.96	2.72	27.11	2.99	4.43	44.15	[illegible]
41.76	2.75	27.76	2.91	4.40	44.21	[illegible]
43.41	2.71	27.29	2.98	4.37	44.40	[illegible]
43.74	2.69	27.30	2.99	4.34	43.93	[illegible]
43.56	2.71	27.40	2.96	4.33	44.15	[illegible]
44.25	2.63	27.16	3.01	4.33	43.76	[illegible]
42.31	2.76	26.24	2.91	4.47	43.44	[illegible]
41.21	2.75	26.24	2.92	4.47	43.42	[illegible]

TABLE A- 3

ESTIMATED GROUP [illegible]

AVERAGE SPEED	MC (GPM)	CO (GPM)	NOX (GPM)	HC (GPM)	[illegible] (GPM)	[illegible] (GPM)
19.36	4.14	38.19	.38	.55	51.[illegible]	.[illegible]
19.60	4.05	37.1[illegible]	2.30	.53	52.54	[illegible]
19.84	4.05	37.[illegible]	.42	.52	50.[illegible]	[illegible]
19.97	3.98	36.43	2.27	.43	53.[illegible]	[illegible]
19.98	4.[illegible]	35.77	2.33	.[illegible]	54.[illegible]	.[illegible]
19.13	3.96	33.37	2.23	.53	47.[illegible]	[illegible]
20.02	3.[illegible]	28.99	2.21	.28	43.[illegible]	[illegible]
19.04	3.90	31.31	2.30	.[illegible]	53.[illegible]	[illegible]
19.33	3.[illegible]	30.60	2.26	.53	49.[illegible]	[illegible]
18.[illegible]	3.[illegible]	32.[illegible]	2.1[illegible]	.[illegible]	47.[illegible]	[illegible]
19.00	3.94	31.73	2.26	.[illegible]	51.[illegible]	[illegible]
19.15	3.86	32.17	2.31	.[illegible]	[illegible]	[illegible]
18.[illegible]	[illegible]	31.[illegible]	2.[illegible]	.[illegible]	[illegible]	[illegible]
19.20	3.[illegible]	31.27	2.32	.[illegible]	[illegible]	[illegible]
20.27	3.34	29.[illegible]	2.[illegible]	.37	47.[illegible]	[illegible]
19.[illegible]	3.93	31.73	2.29	.[illegible]	51.[illegible]	[illegible]
19.[illegible]	3.[illegible]	29.[illegible]	.[illegible]	.[illegible]	47.77	[illegible]
18.[illegible]	[illegible]	31.[illegible]	2.[illegible]	.[illegible]	[illegible]	[illegible]
19.[illegible]	3.[illegible]	30.[illegible]	2.[illegible]	.57	[illegible]	[illegible]
20.[illegible]	3.[illegible]	29.[illegible]	2.21	.[illegible]	47.[illegible]	[illegible]
18.[illegible]	[illegible]	31.[illegible]	2.[illegible]	.[illegible]	[illegible]	[illegible]
19.[illegible]	[illegible]	[illegible]	[illegible]	.[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	27.[illegible]	[illegible]	.[illegible]	47.[illegible]	[illegible]
19.[illegible]	[illegible]	31.[illegible]	[illegible]	.[illegible]	51.[illegible]	[illegible]
[illegible]	[illegible]	31.[illegible]	[illegible]	.[illegible]	[illegible]	[illegible]
19.[illegible]	[illegible]	31.29	[illegible]	.[illegible]	[illegible]	[illegible]
19.[illegible]	[illegible]	31.[illegible]	[illegible]	.[illegible]	[illegible]	[illegible]
18.[illegible]	[illegible]	31.[illegible]	2.[illegible]	.[illegible]	51.[illegible]	[illegible]
20.[illegible]	[illegible]	29.[illegible]	[illegible]	.[illegible]	[illegible]	[illegible]
20.[illegible]	[illegible]	29.[illegible]	[illegible]	.[illegible]	[illegible]	[illegible]
20.[illegible]	[illegible]	28.61	[illegible]	.[illegible]	[illegible]	[illegible]

TABLE A- 3 (CONTINUED)

ESTIMATED GRIDDED EMISSIONS

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AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPV)	CO (GPV)	NOX (GPM)
22.98	3.00	27.27	2.46	4.53	43.38	3.76
22.23	3.07	27.50	2.35	4.94	44.25	3.79
23.47	2.91	25.37	2.26	4.69	41.79	3.67
24.15	2.88	25.83	2.39	4.63	41.57	3.85
24.95	2.91	25.89	2.53	4.68	41.56	4.07
23.56	2.92	26.06	2.33	4.70	41.94	3.75
23.47	2.95	26.42	2.37	4.74	42.52	3.82
22.71	3.05	27.45	2.46	4.92	44.17	3.95
23.83	2.90	25.89	2.35	4.67	41.67	3.78
25.45	2.83	25.40	2.53	4.55	40.37	4.07
22.67	3.01	26.84	2.31	4.84	43.28	3.72
20.92	3.24	29.15	2.38	5.21	46.46	3.83
24.64	2.83	25.26	2.36	4.55	40.66	3.79
26.15	2.59	23.34	2.53	4.16	37.56	4.07
27.70	2.64	23.71	2.55	4.24	38.16	4.10
28.43	2.54	23.05	2.52	4.09	37.10	4.06
30.04	2.47	22.37	2.54	3.98	36.04	4.11
30.62	2.43	21.99	2.57	3.91	35.39	4.13
27.25	2.68	24.32	2.66	4.31	38.14	4.19
29.58	2.49	22.48	2.55	4.01	36.18	4.11
28.40	2.59	23.65	2.63	4.17	38.06	4.24
27.28	2.64	23.73	2.48	4.25	38.19	3.99
26.11	2.72	24.39	2.46	4.38	39.27	4.00
27.52	2.62	23.68	2.51	4.22	38.10	4.04
28.33	2.60	23.49	2.59	4.18	37.81	4.18
27.16	2.67	24.29	2.58	4.30	39.09	4.15
32.99	2.30	21.08	2.65	3.70	33.93	4.26
30.66	2.43	21.85	2.59	3.87	35.17	4.13
32.12	2.34	21.25	2.59	3.76	34.20	4.16
30.80	2.41	21.69	2.52	3.87	34.91	4.06

TABLE A- 3 (CONTINUED)

ESTIMATED GROUP 3 EMISSIONS

AVERAGE SPEED	HC (GPM)	CO (GPM)	NOX (GPM)	PM (GPM)	CO2 (GPM)	SO2 (GPM)
34.59	2.36	21.33	2.63	3.50	34.73	+.22
33.71	2.26	20.63	2.62	3.66	33.20	+.21
31.00	2.41	21.92	2.61	3.38	35.26	+.22
31.10	2.42	22.07	2.64	3.89	35.52	+.24
31.52	2.37	21.38	2.54	3.81	34.41	+.16
31.00	2.36	21.30	2.55	3.35	34.58	+.16
30.68	2.43	22.32	2.58	3.91	35.44	+.15
29.60	2.41	22.28	2.51	3.98	35.30	+.13
41.68	1.95	17.56	2.67	3.14	28.74	+.13
43.26	1.92	17.51	2.71	3.08	28.67	+.17
41.95	1.95	17.92	2.71	3.14	29.04	+.18
44.14	1.91	17.14	2.68	3.03	28.52	+.21
43.20	1.93	17.51	2.71	3.07	29.27	+.19
42.50	1.93	17.17	2.72	3.11	29.02	+.17
42.43	1.95	17.91	2.74	3.14	29.82	+.21
44.01	1.88	17.42	2.77	3.03	28.43	+.21
45.48	1.85	17.31	2.80	2.99	27.88	+.21
44.37	1.89	17.33	2.72	3.05	27.99	+.21
41.63	1.95	18.03	2.72	3.14	29.32	+.19
44.31	1.89	17.46	2.74	3.03	28.12	+.19
42.98	1.93	17.98	2.75	3.11	28.65	+.20
41.76	1.94	17.82	2.68	3.13	29.05	+.21
43.41	1.92	17.97	2.75	3.08	29.44	+.19
43.74	1.90	17.51	2.73	3.03	28.27	+.19
43.05	1.91	17.62	2.74	3.04	28.28	+.21
44.23	1.89	17.34	2.71	3.09	29.14	+.17
42.37	1.96	18.02	2.74	3.15	29.31	+.18
41.21	1.97	18.03	2.69	3.13	29.02	+.17

TABLE A- 4

ESTIMATED GROUP 4 EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPM)	CO (GPM)	NOX (GPM)
15.36	3.99	50.02	3.05	0.62	31.47	0.40
15.80	3.89	49.18	3.05	0.26	19.15	0.91
15.84	3.89	49.34	3.10	0.26	19.41	0.92
15.97	3.77	48.15	2.95	0.07	17.45	0.14
15.98	3.82	48.80	3.00	0.15	18.32	0.53
19.13	3.16	40.30	2.87	0.11	05.34	0.02
20.60	3.03	38.35	2.90	4.08	01.69	0.22
19.04	3.21	41.39	2.95	0.27	05.01	0.75
19.35	3.20	40.59	2.89	0.18	05.32	0.03
18.89	3.21	40.72	2.78	0.17	05.53	0.03
18.00	3.27	41.89	2.90	0.21	07.01	0.07
18.09	3.42	43.52	2.97	0.21	19.04	0.19
18.61	3.21	41.07	2.89	0.27	07.02	0.09
19.23	3.20	41.49	2.95	0.24	06.77	0.04
20.22	3.09	39.19	2.92	4.97	03.06	0.71
18.60	3.27	41.77	2.89	0.20	07.22	0.05
19.07	3.08	38.39	2.76	4.90	02.79	0.01
18.80	3.30	41.56	2.93	0.31	07.35	0.14
19.46	3.24	40.85	2.99	0.21	05.19	0.03
20.59	3.02	38.50	2.91	4.86	02.06	0.00
18.72	3.32	42.15	2.95	0.35	07.85	0.12
19.27	3.15	40.14	2.86	0.07	04.59	0.00
20.29	3.10	39.24	2.93	4.84	03.15	0.12
18.96	3.27	41.32	2.93	0.27	06.30	0.16
19.02	3.25	41.29	2.92	0.23	06.05	0.10
18.63	3.34	42.22	2.97	0.37	07.94	0.17
18.81	3.32	42.18	2.96	0.34	07.89	0.15
20.32	3.12	39.53	2.97	4.32	03.07	0.16
20.37	3.08	38.85	2.93	4.15	02.54	0.11
20.84	2.95	37.23	2.81	4.12	99.91	0.22

TABLE A- 4 (CONTINUED)

ESTIMATED GROUP 4 EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPM)	CO (GPM)	NOX (GPM)
22.98	2.76	35.25	3.11	4.43	50.73	5.33
24.23	2.82	35.74	2.99	4.34	51.51	4.32
23.41	2.84	33.80	2.90	4.25	54.34	4.66
24.15	2.62	33.42	3.02	4.22	53.79	4.85
24.95	2.66	33.97	3.11	4.27	54.67	5.13
23.56	2.68	33.77	2.95	4.35	54.34	4.76
23.47	2.69	34.42	3.00	4.32	55.60	4.84
22.77	2.83	35.83	3.11	4.55	57.66	5.00
23.83	2.65	33.62	2.97	4.26	54.11	4.78
23.45	2.57	32.39	3.18	4.13	52.93	5.14
22.67	2.74	34.92	2.94	4.40	56.21	4.74
20.92	2.99	36.11	3.03	4.01	51.33	4.07
24.64	2.57	32.67	2.99	4.14	52.89	4.79
26.15	2.31	29.67	3.16	3.72	47.75	5.08
27.70	2.38	30.28	3.18	3.82	48.73	5.11
28.43	2.25	28.90	3.15	3.63	45.91	5.08
30.04	2.19	28.17	3.22	3.53	45.34	5.18
30.62	2.15	27.73	3.19	3.45	44.55	5.14
27.25	2.42	31.16	3.24	3.89	50.14	5.21
24.56	2.20	28.17	3.18	3.54	43.53	5.11
25.40	2.32	30.03	3.28	3.74	48.33	5.32
27.23	2.37	30.36	3.11	3.82	48.89	5.01
26.11	2.45	31.41	3.11	3.93	50.55	5.01
27.52	2.35	30.10	3.15	3.73	48.44	5.04
28.33	2.34	29.96	3.21	3.7	48.25	5.17
27.10	2.42	31.11	3.21	3.89	50.37	5.17
32.95	2.02	26.11	3.27	3.25	42.02	5.23
30.06	2.17	27.39	3.17	3.41	44.06	5.11
32.12	2.04	26.50	3.20	3.29	42.55	5.13
30.80	2.11	27.32	3.14	3.43	43.18	5.05

TABLE A- 4 (CONTINUED)

ESTIMATED GROUP 4 EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPM)	CO (GPM)	LEAD (GPM)
31.95	2.08	27.10	3.24	2.06	43.70	0.02
33.71	1.98	25.92	3.24	2.18	41.23	0.01
31.03	2.13	27.42	3.24	2.43	44.12	0.01
31.10	2.14	27.75	3.20	2.44	44.60	0.02
31.52	2.08	26.82	3.10	2.25	43.15	0.01
31.00	2.10	27.14	3.17	2.39	43.07	0.01
30.66	2.10	27.74	3.20	2.40	44.71	0.01
29.66	2.19	28.10	3.12	2.52	45.33	0.01
41.08	1.65	21.31	3.30	2.05	34.02	0.01
43.26	1.61	21.17	3.39	2.00	34.07	0.02
41.98	1.65	21.56	3.31	2.05	34.74	0.01
44.14	1.62	21.27	3.42	2.00	34.23	0.01
43.20	1.61	21.39	3.32	2.00	33.94	0.01
42.50	1.63	21.30	3.33	2.02	34.27	0.01
42.43	1.65	21.36	3.35	2.06	34.66	0.01
44.61	1.57	20.59	3.39	2.03	33.13	0.01
45.46	1.59	20.26	3.42	2.03	32.03	0.01
44.07	1.56	20.62	3.33	2.05	33.13	0.01
41.63	1.62	21.53	3.33	2.06	34.06	0.01
44.01	1.58	20.91	3.33	2.03	33.49	0.01
42.99	1.63	21.31	3.36	2.02	34.10	0.01
41.75	1.63	21.36	3.26	2.63	34.41	0.01
43.41	1.61	21.16	3.36	2.59	34.36	0.01
43.71	1.59	20.89	3.35	2.57	33.92	0.01
43.56	1.60	21.03	3.35	2.58	33.65	0.01
44.23	1.58	20.81	3.38	2.54	33.49	0.01
42.07	1.66	21.74	3.35	2.07	34.49	0.01
41.21	1.67	21.71	3.36	2.08	34.93	0.01

TABLE A- 5

ESTIMATED GROUP 5 EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPM)	CO (GPM)	NOX (GPM)
15.36	3.61	92.91	4.10	5.51	60.23	.07
15.80	3.54	91.39	4.18	5.57	58.87	.07
15.99	3.52	91.35	4.15	5.61	58.34	.07
15.71	3.55	90.21	3.96	5.63	56.33	.07
15.46	3.43	90.31	4.03	5.52	58.17	.07
19.13	2.80	72.39	3.55	4.64	46.30	.06
20.03	2.71	69.92	3.37	4.49	43.12	.05
19.39	2.96	73.07	3.95	4.79	53.21	.06
19.45	2.99	72.33	3.98	4.78	52.56	.06
18.09	2.96	72.13	3.72	4.71	52.17	.06
18.58	2.97	73.51	3.83	4.77	53.13	.06
18.19	3.03	73.15	3.97	4.80	56.69	.06
18.01	2.96	73.45	3.94	4.77	55.55	.06
19.75	2.96	72.47	4.08	4.78	52.[illegible]	.06
20.44	2.82	80.30	3.91	4.39	52.33	.06
19.80	2.91	73.56	3.86	4.71	54.[illegible]	.06
19.61	2.91	80.39	3.72	4.[illegible]	52.[illegible]	.06
18.56	3.01	83.99	3.92	4.[illegible]	56.[illegible]	.06
19.98	2.95	82.58	4.01	4.71	52.13	.06
20.30	2.89	80.28	3.80	4.[illegible]	53.[illegible]	.06
18.12	2.93	83.78	3.95	4.81	54.[illegible]	.06
20.21	2.81	82.15	3.82	4.62	51.[illegible]	.06
20.29	2.85	83.19	3.92	4.25	49.[illegible]	.06
18.44	2.91	82.28	3.83	4.71	53.[illegible]	.06
19.62	2.96	83.07	3.94	4.71	55.[illegible]	.06
18.83	3.03	83.83	4.35	4.81	54.[illegible]	.06
19.31	3.01	83.62	3.99	4.99	54.[illegible]	.06
20.36	2.89	80.89	3.80	4.61	49.[illegible]	.06
20.37	2.83	80.65	3.92	4.54	45.[illegible]	.06
20.[illegible]	2.80	79.[illegible]	3.79	4.51	41.[illegible]	.06

TABLE A- 5 (CONTINUED)

ESTIMATED GROUP 5 EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPM)	CO (GPM)	NOX (GPM)
22.58	2.54	27.31	4.12	4.33	43.59	0.68
22.63	2.50	27.53	3.97	4.10	44.23	0.65
23.41	2.44	25.89	3.84	3.92	41.87	0.63
24.15	2.43	25.92	3.89	3.93	41.97	0.64
24.95	2.45	25.32	4.20	3.94	40.75	0.67
25.50	2.45	25.91	3.92	3.93	41.[illegible]	0.63
23.47	2.48	26.87	3.97	3.95	42.44	0.63
22.77	2.61	27.61	4.12	4.19	44.44	0.66
23.83	2.45	25.72	3.94	3.94	41.32	0.63
25.45	2.37	24.55	4.20	3.82	39.67	0.70
27.27	2.51	27.36	3.90	4.05	43.45	0.71
28.72	2.73	30.30	4.02	4.39	48.28	0.71
24.04	2.38	24.70	3.94	3.[illegible]	40.[illegible]	0.66
28.15	2.16	21.39	4.15	3.47	35.17	0.67
21.76	2.21	22.31	4.16	3.56	36.00	0.73
26.43	2.10	21.32	4.14	3.38	34.27	0.68
30.04	2.05	20.40	4.22	3.21	32.95	0.75
30.02	2.01	19.97	4.13	3.24	32.14	0.67
27.79	2.25	23.13	4.26	3.62	37.[illegible]	0.69
29.56	2.05	20.45	4.17	3.30	32.[illegible]	0.71
28.40	2.17	22.15	4.29	3.50	35.09	0.66
27.28	2.21	22.34	4.10	3.56	35.28	0.65
26.11	2.27	23.56	4.11	3.66	37.[illegible]	0.64
27.52	2.18	22.26	4.12	3.51	35.[illegible]	0.64
28.34	2.16	22.03	4.23	3.51	35.40	0.66
27.10	2.25	23.11	4.24	3.63	37.[illegible]	0.68
32.91	1.91	18.50	4.23	3.07	29.[illegible]	0.68
30.66	1.96	19.33	4.15	3.21	31.[illegible]	0.65
32.12	1.92	18.91	4.19	3.10	30.[illegible]	0.[illegible]
30.20	1.90	19.04	4.11	3.19	31.[illegible]	0.[illegible]

TABLE A- 5 (CONTINUED)

ESTIMATED GROUP 5 EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPM)	CO (GPM)	NOX (GPM)
31.99	1.96	19.60	4.24	3.12	31.23	6.77
33.71	1.97	17.96	4.24	3.00	28.14	6.62
31.00	2.00	19.79	4.24	3.22	31.64	6.83
31.10	2.01	19.94	4.23	3.23	32.13	6.81
31.52	1.96	19.19	4.14	3.13	30.36	6.67
31.30	1.96	19.56	4.15	3.18	31.91	6.77
30.66	2.03	20.37	4.20	3.27	32.36	6.78
29.66	2.05	20.46	4.16	3.30	32.92	6.71
31.38	1.99	14.19	4.28	2.56	22.43	6.69
33.26	1.96	13.90	4.40	2.51	22.37	7.07
31.93	1.95	14.23	4.36	2.55	22.91	6.97
33.14	1.97	13.84	4.44	2.52	22.27	7.15
33.20	1.96	13.75	4.31	2.51	22.13	6.94
34.30	1.97	14.31	4.32	2.52	22.35	6.76
32.63	1.99	14.16	4.36	2.57	22.74	7.11
34.31	1.92	13.35	4.39	2.45	21.43	7.07
33.90	1.91	13.11	4.33	2.42	21.13	7.13
34.07	1.93	13.33	4.32	2.46	21.46	6.79
31.03	1.99	14.32	4.32	2.55	23.04	6.91
33.01	1.93	13.92	4.34	2.46	21.71	6.91
32.99	1.97	13.97	4.37	2.52	22.43	7.03
31.76	1.97	14.10	4.26	2.53	22.70	6.86
33.91	1.96	13.82	4.36	2.51	22.09	7.01
33.71	1.99	13.93	4.35	2.43	21.93	7.02
33.33	1.93	13.72	4.36	2.50	22.08	7.01
33.35	1.93	13.93	4.33	2.46	21.75	7.01
32.07	1.96	14.37	4.35	2.58	23.12	7.03
31.21	1.98	14.38	4.28	2.56	23.12	6.89

TABLE A- 6

ESTIMATED GROUP [illegible] EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	PM (GPK)	CO2 (GPK)	FUEL (GPK)
15.36	2.07	34.50	3.05	0.30	561.35	0.
15.80	2.01	33.06	3.69	0.20	564.17	0.
15.89	2.02	33.71	3.75	0.21	564.25	0.
15.97	2.04	32.71	3.54	0.17	552.54	0.
15.98	2.07	32.35	3.62	0.19	553.02	0.
16.13	2.12	26.56	3.49	0.21	542.52	0.
20.00	2.05	24.40	3.54	0.37	537.26	0.
19.04	2.24	27.05	3.60	0.21	543.34	0.
19.35	2.20	26.36	3.52	0.23	542.43	0.
19.85	2.19	26.60	3.56	0.22	542.59	0.
19.96	2.25	27.37	3.53	0.21	544.33	0.
20.05	2.33	28.88	3.61	0.25	550.44	0.
19.81	2.24	27.26	3.51	0.20	543.21	0.
19.66	2.24	27.34	3.63	0.21	543.59	0.
20.22	2.13	25.17	3.57	0.23	540.21	0.
19.80	2.24	27.31	3.51	0.20	544.35	0.
19.67	2.11	25.10	3.39	0.20	539.43	0.
19.80	2.25	27.30	3.51	0.22	543.03	0.
19.46	2.23	26.50	3.64	0.22	542.41	0.
20.50	2.10	24.77	3.59	0.37	539.36	0.
19.72	2.27	27.70	3.60	0.25	544.38	0.
19.27	2.17	26.23	3.43	0.24	542.21	0.
20.29	2.14	25.16	3.58	0.24	540.49	0.
19.83	2.24	26.94	3.56	0.20	543.50	0.
19.02	2.23	27.01	3.55	0.24	543.41	0.
18.82	2.23	27.69	3.62	0.27	544.55	0.
19.91	2.20	27.57	3.62	0.26	544.36	0.
20.26	2.15	25.37	3.63	0.21	543.33	0.
20.37	2.13	24.99	3.57	0.22	543.25	0.
20.34	2.03	23.35	3.43	0.27	538.17	0.

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TABLE A- [illegible]

ESTIMATED [illegible] PRESSURES

[illegible]	[illegible] (PSIA)	[illegible] (PSIA)	N.A. (PSIA)	[illegible] (PSIA)	[illegible] (PSIA)	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE A- 6 (CONTINUED)

ESTIMATED GROUP [illegible] EMISSIONS

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AVERAGE SPEED	HC (GPM)	CO (GPM)	NOX (GPM)	HC (GPM)	CO (GPM)	A (GPM)
31.05	1.37	12.79	4.30	2.93	25.34	[illegible]
33.71	1.31	14.45	4.39	2.93	23.83	[illegible]
31.03	1.40	15.76	4.60	2.97	25.58	[illegible]
31.10	1.41	16.15	4.11	2.97	23.39	[illegible]
31.32	1.36	15.47	3.98	2.92	24.36	[illegible]
31.00	1.38	15.76	3.96	2.94	25.30	[illegible]
30.66	1.41	16.29	4.03	2.80	26.15	[illegible]
29.60	1.42	16.31	3.92	2.81	26.57	[illegible]
31.08	1.32	11.28	4.21	2.13	18.15	[illegible]
33.20	1.31	11.30	4.33	2.11	17.73	[illegible]
31.99	1.32	11.31	4.23	2.13	18.21	[illegible]
34.19	1.32	11.37	4.37	2.12	17.82	[illegible]
33.20	1.30	10.73	4.24	2.10	17.57	[illegible]
32.70	1.31	11.17	4.25	2.11	17.90	[illegible]
32.93	1.32	11.27	4.28	2.14	18.14	[illegible]
36.31	1.28	10.54	4.33	2.07	16.40	[illegible]
33.50	1.27	10.29	4.38	2.05	16.55	[illegible]
34.37	1.28	10.53	4.25	2.07	16.85	[illegible]
31.53	1.32	11.31	4.25	2.13	18.20	[illegible]
34.01	1.29	10.72	4.23	2.05	17.25	[illegible]
32.22	1.32	11.11	4.29	2.12	17.87	[illegible]
31.70	1.31	11.16	4.18	2.11	17.96	[illegible]
33.21	1.31	10.98	4.29	2.10	17.37	[illegible]
31.71	1.33	10.79	4.25	2.09	17.17	[illegible]
33.30	1.30	10.84	4.25	2.09	17.51	[illegible]
34.25	1.29	10.73	4.32	2.08	17.27	[illegible]
32.37	1.33	11.47	4.27	2.15	18.40	[illegible]
31.21	1.33	11.40	4.20	2.14	18.35	[illegible]

TABLE A- 7

ESTIMATED GROUP I EMISSIONS

AVERAGE SPEED	HC (GPM)	CO (GPM)	NOX (GPM)	HC (GPM)	CO (GPM)	CO2 (GPM)
15.56	2.20	35.47	3.35	3.25	37.39	3.41
15.60	2.24	34.27	3.30	3.23	35.15	3.41
15.64	2.29	34.49	3.43	3.31	35.31	3.45
15.67	2.16	35.51	3.22	3.21	33.71	3.16
15.98	2.21	33.04	3.30	3.33	34.43	3.3
17.43	1.86	27.27	3.13	3.20	43.66	3.41
23.65	1.79	25.36	3.23	3.30	43.63	3.42
17.09	1.91	27.91	3.24	3.00	44.56	3.42
19.35	1.96	27.21	3.22	3.02	43.00	3.17
13.57	1.87	27.31	3.04	3.31	43.45	3.40
13.62	1.92	26.47	3.21	3.04	44.13	3.47
17.03	2.00	29.15	3.27	3.21	47.51	3.5
17.61	1.96	28.25	3.26	3.38	45.33	3.41
17.65	1.96	28.09	3.31	3.03	43.41	3.37
17.65	1.83	26.11	3.26	2.93	42.62	3.3
17.65	1.91	26.31	3.20	3.05	43.24	3.34
17.67	1.85	25.37	3.30	2.93	41.53	3.2
18.0	1.92	26.35	3.28	3.10	43.21	3.34
17.94	1.98	27.91	3.33	3.33	44.27	3.34
17.95	1.79	25.08	3.25	2.88	41.51	3.21
17.72	1.99	26.51	3.26	3.13	43.13	3.3
17.87	1.95	26.36	3.16	3.07	43.23	3.33
18.07	1.93	26.11	3.27	3.04	42.16	3.23
18.17	1.91	27.17	3.25	3.28	44.07	3.4
17.96	1.98	27.76	3.24	3.08	44.71	3.42
17.93	1.93	28.39	3.30	3.19	45.39	3.51
17.87	1.95	28.54	3.30	3.13	43.56	3.31
20.32	1.89	28.34	3.32	3.05	42.37	3.2
20.37	1.84	29.37	4.28	3.06	41.97	3.2
21.39	1.73	29.35	3.13	3.10	39.15	3.1

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TABLE A- 7 (CONTINUED)

ESTIMATED GROUP 7 MISSILES

AVERAGE SPEED	[illegible] (GPS)	[illegible] (GPS)	[illegible] (GPS)	[illegible] (GPS)	[illegible] (GPS)	[illegible] (GPS)
[illegible]	1.31	10.39	3.73	2.11	26.50	.21
33.71	1.26	10.3[illegible]	3.74	2.3[illegible]	24.19	.21
31.90	1.33	10.97	3.73	2.15	20.53	.2[illegible]
31.10	1.33	10.75	3.75	2.16	20.92	.09
31.37	1.30	10.36	3.68	2.13	25.74	.[illegible]
31.00	1.32	10.1[illegible]	3.65	2.[illegible]	25.15	.[illegible]
3[illegible]	1.33	10.77	3.60	2.17	25.[illegible]	.[illegible]
2[illegible]	1.[illegible]	17.38	3.55	2.[illegible]	27.45	.[illegible]
31.3[illegible]	1.39	11.09	3.64	1.75	19.74	.1[illegible]
33.[illegible]	1.37	11.25	3.66	1.72	18.18	.[illegible]
31.93	1.39	11.65	3.6[illegible]	1.75	13.61	.22
3[illegible]	1.[illegible]	11.[illegible]	3.[illegible]	1.[illegible]	15.[illegible]	.[illegible]
3[illegible]	1.[illegible]	11.21	3.67	1.7[illegible]	13.[illegible]	.[illegible]
32.[illegible]	1.[illegible]	11.[illegible]	3.[illegible]	1.[illegible]	13.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	11.[illegible]	3.71	1.[illegible]	13.[illegible]	.[illegible]
3[illegible].[illegible]	1.35	10.82	3.[illegible]	1.[illegible]	17.[illegible]	.[illegible]
32.[illegible]	1.[illegible]	10.[illegible]	3.[illegible]	1.[illegible]	13.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	10.[illegible]	3.[illegible]	1.[illegible]	17.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	11.[illegible]	3.[illegible]	1.[illegible]	13.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	11.[illegible]	3.[illegible]	1.[illegible]	17.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	11.[illegible]	3.72	1.[illegible]	13.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	11.[illegible]	3.[illegible]	1.[illegible]	13.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	11.[illegible]	3.72	1.[illegible]	13.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	11.[illegible]	3.[illegible]	1.[illegible]	17.[illegible]	.[illegible]
3[illegible].[illegible]	1.[illegible]	11.[illegible]	3.[illegible]	1.[illegible]	13

TABLE A-5

ESTIMATED GROUP 3 EMISSIONS

AVERAGE SPEED	HC (GPM)	CO (GPM)	NOX (GPM)	HC (GPM)	CO (GPM)	NOX (GPM)
15.28	4.09	83.68	1.52	5.58	134.07	2.44
15.80	4.01	82.04	1.53	5.43	132.04	2.46
15.82	4.09	83.34	1.54	5.50	134.12	2.47
15.97	3.87	78.24	1.53	5.24	125.50	2.47
15.98	3.92	80.35	1.53	5.35	129.23	2.47
17.13	3.81	69.29	1.57	5.47	111.51	2.53
20.80	3.84	69.10	1.52	5.37	111.20	2.47
17.04	3.93	72.89	1.53	5.05	117.30	2.47
19.39	3.90	71.13	1.52	5.27	114.48	2.44
18.89	3.93	69.57	1.46	5.23	112.13	2.35
18.66	3.91	71.92	1.54	5.32	115.74	2.48
18.92	3.89	75.28	1.53	5.56	121.15	2.47
18.81	3.90	71.41	1.54	5.09	114.93	2.48
19.26	3.91	73.23	1.55	5.05	117.85	2.49
20.65	3.95	70.13	1.54	5.44	112.85	2.48
18.96	3.94	71.56	1.54	5.53	115.15	2.48
17.67	3.93	67.46	1.49	5.36	108.57	2.40
18.66	3.95	73.01	1.52	5.71	117.50	2.45
19.98	3.91	73.30	1.53	5.64	117.91	2.46
23.53	3.91	68.37	1.57	5.33	110.04	2.53
18.72	3.97	74.38	1.52	5.74	119.23	2.44
19.27	3.89	68.82	1.56	5.42	110.72	2.51
20.29	3.96	70.83	1.52	5.47	114.00	2.44
19.98	3.91	72.24	1.52	5.56	116.25	2.44
19.62	3.89	71.73	1.54	5.62	115.44	2.47
18.63	3.96	74.01	1.54	5.76	119.21	2.49
19.07	3.91	74.18	1.54	5.75	119.38	2.49
20.32	3.93	71.99	1.53	5.51	115.72	2.47
20.17	3.97	69.81	1.53	5.42	112.34	2.47
23.34	3.93	65.09	1.50	5.16	104.75	2.42

TABLE A-8 (CONTINUED)

ESTIMATED GROUP 8 EMISSIONS

AVERAGE SPEED	HC (GPK)	CO (GPK)	NOX (GPK)	HC (GPH)	CO (GPH)	NOX (GPH)
22.98	3.17	65.04	1.80	5.09	105.04	2.90
23.23	3.17	65.57	1.84	5.13	105.92	2.92
23.47	3.02	62.02	1.68	4.86	99.84	2.71
24.15	3.05	63.05	1.75	4.91	101.48	2.83
24.59	3.14	65.55	1.74	5.05	105.72	2.80
23.58	3.05	62.02	1.71	4.91	100.21	2.75
23.47	3.09	64.06	1.72	4.97	103.10	2.76
22.71	3.24	66.09	1.71	5.21	106.37	2.75
23.83	3.09	63.06	1.70	4.91	101.48	2.74
25.45	3.26	64.62	1.72	4.91	104.32	2.77
22.61	3.10	63.02	1.69	5.00	102.22	2.71
20.82	3.32	68.44	1.84	5.39	110.15	2.91
24.66	2.99	62.25	1.73	4.82	100.19	2.78
25.15	2.96	59.54	1.92	4.58	95.82	3.05
27.10	3.21	61.16	1.89	4.60	95.45	3.04
28.43	2.98	57.53	1.96	4.56	92.59	3.15
30.09	2.77	58.14	1.95	4.45	93.98	3.15
31.42	2.73	57.19	1.93	4.39	92.34	3.09
27.43	2.95	62.54	1.93	4.73	100.30	3.11
29.58	2.77	57.51	1.97	4.49	92.53	3.17
29.94	2.85	61.33	1.99	4.85	98.32	3.20
27.36	2.87	60.31	1.87	4.83	96.87	3.01
26.11	2.96	60.95	1.87	4.73	97.39	3.01
27.37	2.87	59.87	1.90	4.62	95.32	3.14
28.53	2.88	58.48	1.93	4.44	93.10	3.11
27.10	2.95	62.39	1.92	4.74	99.73	3.03
25.19	2.83	55.65	2.05	4.27	89.40	3.27
31.85	2.90	55.94	2.01	4.55	90.10	3.23
32.14	2.69	55.59	2.04	4.27	89.14	3.26
32.39	2.69	56.06	1.97	4.33	90.16	3.17

TABLE A- 8 (CONTINUED)

ESTIMATED GROUP 8 EMISSIONS

AVERAGE SPEED	HC (GPM)	CO (GPM)	NOX (GPM)	HC (GPM)	CO (GPM)	NOX (GPM)
31.55	2.02	55.39	2.03	4.55	91.20	3.4
33.71	2.01	54.34	2.01	4.50	89.25	3.4
31.60	2.15	57.31	2.05	4.43	92.23	3.4
32.10	2.19	57.59	2.04	4.42	93.17	3.4
31.92	2.17	55.79	1.99	4.29	89.73	3.2
31.55	2.16	55.71	2.01	4.31	89.56	3.4
31.66	2.14	57.01	1.95	4.41	92.12	3.4
32.00	2.14	57.30	1.94	4.41	91.72	3.4
31.88	2.17	56.09	2.20	4.82	97.51	3.9
33.20	2.32	56.37	2.26	4.54	90.53	3.6
31.78	2.38	56.26	2.22	4.53	90.59	3.7
34.14	2.36	51.16	2.26	4.34	82.63	3.4
43.20	2.45	49.81	2.22	4.74	83.15	3.4
42.58	2.46	49.71	2.24	4.80	83.95	3.4
42.93	2.43	50.37	2.22	4.89	84.87	3.4
44.21	2.39	49.31	2.25	4.77	79.55	3.3
45.98	2.39	49.13	2.32	4.75	79.37	3.4
44.27	2.33	49.16	2.23	4.75	79.12	3.3
41.15	2.36	49.33	2.24	4.69	80.49	3.4
44.21	2.33	49.28	2.26	4.73	79.50	3.3
42.09	2.37	50.20	2.25	4.83	81.35	3.3
44.16	2.38	49.32	2.21	4.73	79.35	3.3
43.21	2.36	50.05	2.25	4.80	80.65	3.4
43.71	2.45	49.40	2.27	4.75	79.22	3.3
43.80	2.34	49.76	2.25	4.73	80.03	3.3
44.17	2.39	49.36	2.24	4.72	79.99	3.3
42.21	2.42	50.41	2.23	4.75	81.42	3.3
41.31	2.34	50.31	2.15	4.59	80.36	3.3

TABLE A-9

ESTIMATED GROUP 9 EMISSIONS

AVERAGE SPEED	HC (GPM)	CO (GPM)	NOX (GPM)	HC (GPM)	CO (GPM)	NOX (GPM)
10.00	3.43	59.70	1.31	5.03	95.40	2.01
15.00	3.37	58.41	1.82	4.97	94.10	2.77
15.00	3.44	59.91	1.85	5.01	96.41	2.77
15.71	3.00	55.63	1.76	4.33	87.52	2.64
15.00	3.06	57.60	1.76	4.42	88.33	2.64
17.13	2.63	49.22	1.18	3.27	79.21	2.27
20.00	2.57	49.22	1.10	3.14	79.21	2.10
19.09	2.71	51.97	1.60	3.37	84.51	2.57
19.59	2.87	56.56	1.77	3.50	84.25	2.65
15.03	2.81	53.35	1.72	3.52	75.76	2.75
15.00	2.72	51.55	1.70	3.38	83.13	2.53
18.05	2.91	53.97	1.83	3.32	85.05	2.91
13.71	2.74	50.49	1.76	3.37	82.36	2.64
17.01	2.70	52.03	1.81	3.39	84.11	2.71
20.27	2.93	55.38	1.80	3.13	80.65	2.70
13.00	2.72	51.19	1.70	3.35	82.56	2.55
17.01	2.56	47.30	1.67	3.15	77.23	2.51
13.00	2.71	51.30	1.79	3.40	83.31	2.69
17.00	2.[illegible]	52.13	1.82	3.51	83.54	2.73
20.23	2.97	55.79	1.91	3.12	72.65	2.24
13.72	2.73	52.35	1.77	3.42	83.12	2.66
17.01	2.64	49.30	1.67	3.23	77.22	2.51
21.75	3.01	53.21	1.79	3.23	81.01	2.55
13.00	2.75	51.70	1.76	3.33	82.22	2.64
17.00	2.[illegible]	52.00	1.80	3.39	81.03	2.64
13.03	2.72	52.48	1.80	3.43	85.21	2.69
17.07	2.75	53.31	1.80	3.43	85.00	2.69
20.14	3.00	57.11	1.80	3.53	83.33	2.69
23.07	3.08	59.17	1.73	3.41	79.45	2.57
25.14	3.30	65.75	1.77	3.33	77.23	2.[illegible]

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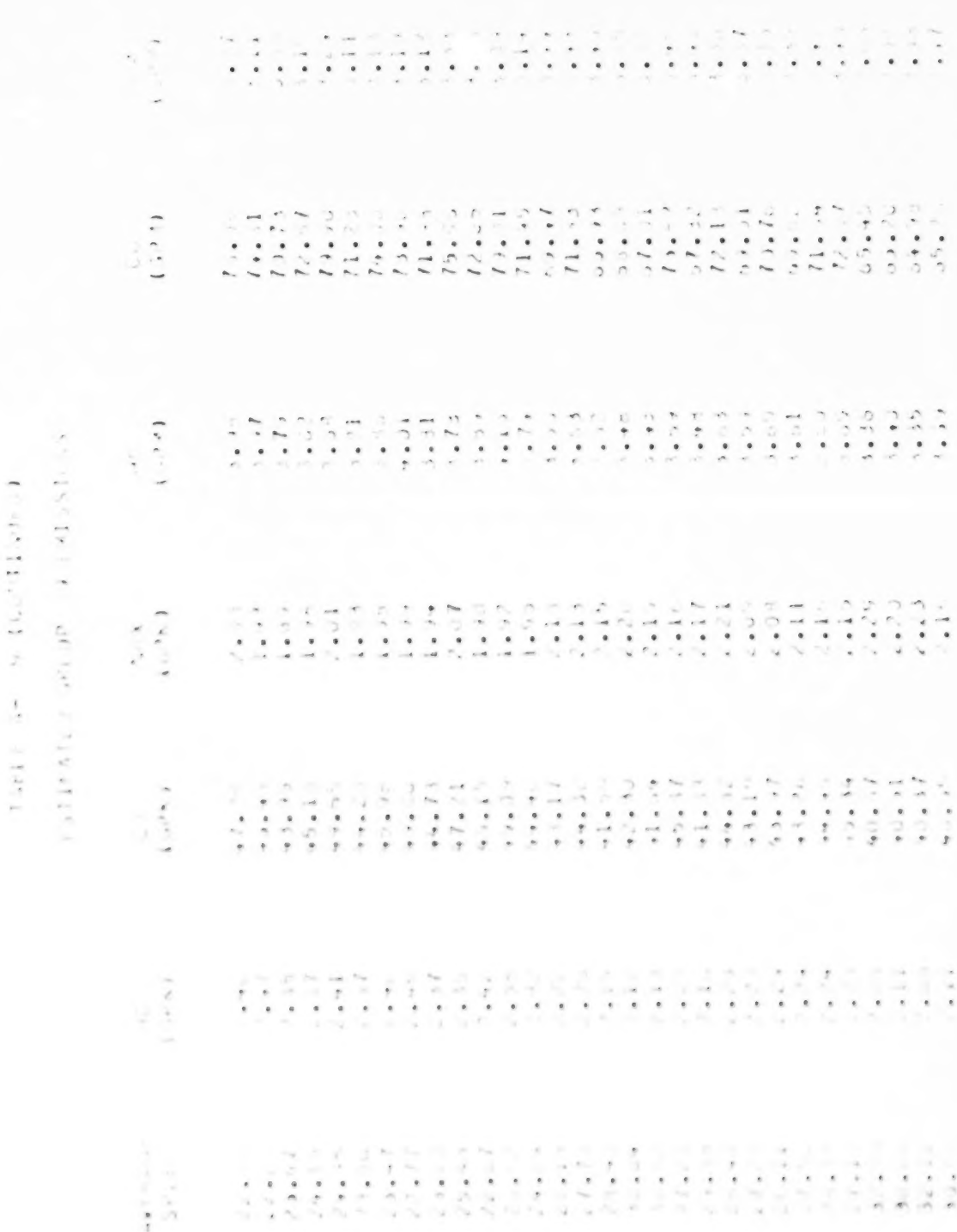

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